Brown AND Caldwell

1580 Sawgrass Corporate Parkway, Suite 400
Sunrise, FL 33323

T: 954.200.7611

Technical Memorandum

Prepared for: Regional Biosolids Solution Working Group

Project Title: Biosolids Conceptual Study

Project No.: 169896

Technical Memorandum

Subject: Regional Biosolids Solution Conceptual Study

Date: May 1, 2024

To: Regional Biosolids Solution Working Group

From: Brown and Caldwell

Prepared by:

Tracy Chouinard, PhD, PE (NH)

Joanna Julien, EI

ValaRae Partee, PE (GA)

Sydney Salit, PE

Reviewed by:

Natalie Sierra, PE (MA)

Celia Earle, PhD, BCEEM

John Willis, PhD, PE

Marie Burbano, PhD, PE

Limitations:

This document was prepared solely for Regional Biosolids Solution Working Group in accordance with professional standards at the time the services were performed and in accordance with the contract between Regional Biosolids Solution Working Group and Brown and Caldwell dated August 30, 2022. This document is governed by the specific scope of work authorized by Regional Biosolids Solution Working Group; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by Regional Biosolids Solution Working Group and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

List of Additional Contributors

Contributors:

Jeff Kivett, Brown and Caldwell

Persephone Ma, Brown and Caldwell

Mark Drummond, C Solutions

Table of Contents

List of Figures

List of Tables

List of Abbreviations

$/wt	cost per wet ton
%APR	annual percentage rate
AACEI	Association for the Advancement of Cost Engineering International
BEBR	Broward County and Municipal Population Forecast and Allocation Model
BMSC	Broward Municipal Services District
CD	Central District
CFR	Code of Federal Regulations
CMAR	Construction Manager at Risk
CWSRF	Clean Water State Revolving Funds
DBB	Design-Bid-Build
DDS	Drum Dryer System
dtpy	dry tons per year
EPA	Environmental Protection Agency
FAC	Florida Administrative Code
FBI	fluid bed incineration
FDEP	Florida Department of Environmental Protection
kWh	kilowatt-hour
MOU	memorandum of understanding
M	million
mmbtu	million British thermal units
ND	North District
NMP	Nutrient Management Plan
NPC	net present cost
O&M	operation and maintenance
PAN	Plant Available Nitrogen
PDB	Progressive Design-Build
PFAM	Broward County and Municipal Population Forecast and Allocation Model
PFAS	Per- and polyfluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PPP	Public/Private Partnership
RBS	Regional Biosolids Solutions
RECs	renewable energy credits
RINs	renewable identification numbers
RNG	renewable natural gas
RTO	regenerative thermal oxidizer
SD	South District
SRF	State Revolving Funds
SWEET	Solids Water Energy Evaluation Tool
TS	total solids
THP	thermal hydrolysis
VS	volatile solids
WIFIA	Water Infrastructure Finance and Innovation Act
wt	wet tons
wtpy	wet tons per year
WWS	Broward County Water and Wastewater Services
WWTP	Wastewater Treatment Plant

Executive Summary

This report presents the results of a conceptual study conducted by Brown and Caldwell for the Regional Biosolids Solutions (RBS) Workgroup, which consisted of several utilities in Broward County, Florida, to explore potential regional solutions for biosolids management. Biosolids are the solid organic matter recovered from the treatment of domestic wastewater, which can be beneficially reused or disposed of in various ways. The current biosolids management practices in South Florida face several challenges and uncertainties, such as decreasing landfill space, increasing land application costs, new regulations, and environmental impacts. Therefore, a regional approach may offer economies of scale, resource recovery, and risk diversification for the participating utilities.

The scope of this study includes three phases: data development, alternatives analysis, and future. This report covers the first two phases, which were conducted through a series of workshops with the utilities as seen in Table ES-1.

Table ES-1. Project Workshop Schedule

Activity	Description	Date
NTP	Notice to Proceed	May 4, 2023
Workshop 1	Kickoff, Data Request	May 24, 2023
Workshop 2	Data analysis summary, Projection of Future Conditions	July 26, 2023
Workshop 3	Review of Rules and Regulations and Market Assessment	September 27, 2023
Workshop 4	High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration	November 1, 2023
Workshop 5	Review of two (2) alternatives, refined SWEET Model	December 13, 2023
Workshop 6	Site assessment and delivery models	February 7, 2024

Data Gathering and Market Evaluation

The first step of the data development phase involved reviewing the existing and updated legislative requirements for biosolids in Florida and nationwide. Next, the team conducted a preliminary market and value chain review for biosolids in Broward County and the surrounding area. The purpose of this review was to understand the current and future biosolids market and the opportunities for beneficial reuse of biosolids. The review included an analysis of the agricultural and commercial markets, based on data from the Florida Census of Agriculture and a survey of relevant businesses. The review also identified the key drivers and barriers for biosolids use and distribution, such as regulations, costs, public perception, and product quality. The main takeaways from the review were that there is a potential demand for Class AA biosolids products in the landscaping industry, but there are also challenges and uncertainties that need to be addressed.

Next, the team evaluated the existing and future conditions and practices of biosolids in Broward County and its neighboring communities. All utilities within the RBS Workgroup contributed their existing solids data and associated costs. This, with projected population data, was used to project the data out to the design year 2043 (Table ES-2).

Table ES-2. Current Regional Biosolids Solution Workgroup Facilities							
Region	Current Data Summary (average 2020-2022)				Projected Data (2043)		Additional Stabilization Treatment
	Wet Solids (wtpy)	Dry Solids (dtpy)	Percent Total Solids (% TS)	Hauling & Tip fee ($/wt)	Wet Solids (wtpy)	Dry Solids (dtpy)	
Broward County	94,911	14,833	15.63%	$44.48	103,660	16,200	Anaerobic Digestion
Cooper City	3,668	491	13.40%	$37.90	3,730	500	Aerobic digestion
Coral Springs Improvement District	2,546	308	12.10%	$64.00	2,810	340	Aerobic digestion
Town of Davie - System II	2,697	337	12.48%	$55.47	3,040	380	Aerobic digestion
Town of Davie - System I	992	110	11.05%	$55.47	1,090	120	Aerobic digestion
Fort Lauderdale	29,457	5,150	17.48%	$63.36	36,550	6,390	Aerobic digestion
Hollywood	65,179	6,909	10.60%	--	74,620	7,910	Lime stabilization
City of Margate	4,016	657	16.37%	--	4,640	760	Rotating Biological Contactors
City of Miramar	14,130	1,707	12.08%	$37.90	15,480	1,870	Anaerobic Digestion
Pembroke Pines	3,028	485	16.00%	$58.41	3,190	510	Aerobic digestion
Plantation	1,051	129	12.24%	--	1,230	150	Anaerobic Digestion
City of Sunrise - Sawgrass	10,050	1,811	18.02%	$61.43	10,710	1,930	Aerated sludge holding tanks
City of Sunrise - Springtree	3,470	680	19.59%	$61.32	3,680	720	Aerated sludge holding tanks
Total	235,195	33,606	14.29%	$50.82	264,430	37,780	

Note: full size version in Table 4-1 (wtpy = wet tons per year, dtpy = dry tons per year, $/wt = cost per wet tons)

Technology Evaluation

A comprehensive list of available technologies for biosolids stabilization was developed and referred to as the universe of options. The initial universe of options included 19 technologies, which were reduced to seven representative technologies after applying a pass/fail assessment. The remaining technologies were scored by the RBS Workgroup and technical team based on their ability to meet the non-cost goals and objectives, such as producing Class AA biosolids, reducing biosolids volume, and minimizing environmental impacts. The assessment narrowed the viable technologies to four initial technology alternatives for further analysis: thermal hydrolysis, thermal drying, composting, and fluidized bed incineration.

These alternatives were compared using Brown and Caldwell's Solids Water Energy Evaluation Tool (SWEET) model, which estimated the net present cost, energy consumption and or production, and other parameters for each alternative. Based on the SWEET analysis and the non-cost goals and objectives, the team narrowed the alternatives to two final options: thermal drying and thermal hydrolysis. The group also considered hybrid options that combined different technologies to optimize the process and reduce the costs.

Recommended Technology

The RBS Workgroup selected thermal drying as the recommended technology based on the following:

- Proven technology with many successful installations in the U.S.
- Because there are several thermal dryer manufacturers and thermal dryer types, there is a vast range of initial capital costs associated with thermal drying projects. At this estimated dryer facility size the capital cost range can be $200 million (M) to $570M. This study was conservative using higher capital estimates including having thermal dryer redundancy.

- Ease of implementation. The participants visited the Palm Beach County regional thermal drying facility, which has been operating successfully, and were able to ask pertinent questions about the process from the beginning (interlocal agreements, etc.) to the end (construction completion and operation).
- Significant reduction in volume of solids during the thermal drying process as compared to THP while on a cost basis, the THP alternative appears to cost less than thermal drying, the volume reduction manifests itself in the hauling. For instance, in 2043, it is estimated that 91 and 42 trucks per year (at 20 tons per truck) would leave the facility for THP and thermal drying, respectively.
- From a market standpoint, thermal drying produces a sellable product. It should be noted that there are different types of thermal dryers at different costs points as well as different delivery methods. There are some companies that even offer mobile thermal dryers solutions.
- Natural gas consumption and number of units could be reduced by thinking outside the box by utilizing waste heat waste heat from the dryers or trying a new technology such as Elode.
- Finally, as part of the consideration for the thermal dryer selection, if the County had to pivot to address per- and polyfluoroalkyl substances (PFAS) mitigation in sludge, the two most promising and commercially advanced technologies currently on the market, pyrolysis and gasification, require thermal drying as the initial step.

Site Assessment

The group also assessed the site requirements and availability for a regional biosolids facility, considering factors such as land area, zoning, utilities, access, and environmental impacts. The study identified 6 potential sites, listed in Table ES-3, in Broward County that met the minimum criteria and are considered viable for future site evaluations as the project moves into next steps. Based on the recommended technology, at least 5 acres of land is needed for a regional dryer facility. The land requirement can be reduced (3+ acres) if it is located adjacent to an existing wastewater treatment facility.

Table ES-3. Final Sites for Evaluation

Final Selected Site Number	Wastewater treatment plant (WWTP) Service Area	Total Area (Acres)	Site Availability (Vacant / Partially Utilized)	Distance (miles) to:	
				WWTP	Landfill
1	Broward County WWTP	11.39	Partially Utilized	0.15	0.55
2	Broward County WWTP	36.58	Partially Utilized	0.03	0.69
3	Broward County WWTP	3.21	Partially Utilized	0	0.57
4	Broward County WWTP Site	77.09	Partially Utilized	WWTP	0.72
5	Broward County WWTP	22.06	Vacant	0.13	0.57
6	Broward County WWTP	30.99	Partially Utilized	0	0.71

Delivery Models

Finally, different delivery and governance models for the regional facility were analyzed, such as utility control, participation in an existing regional system, or public-private partnership. The study discussed the advantages and disadvantages of each model in terms of risk allocation, financing, ownership, and operation.

Next Steps

The next steps involve determining the participating partners, developing a conceptual design, and establishing governance agreements for the regional biosolids facility. Stakeholder engagement is critical, as well as public education, throughout the process. Participating utilities will have off-ramps throughout the process from the time of this study until final design, but those that continue will be instrumental in designing a regional solution that benefits the future of biosolids management in Broward County.

Section 1: Introduction

1.1 Project Overview

Processing and disposal of domestic wastewater biosolids has long been a challenging activity for South Florida utilities. South Florida utilities currently use a mix of land application and landfills to dispose of biosolids.

The future of biosolids handling and disposal is uncertain in view of:

- Decreasing landfill space for biosolids;
- A decreasing number of potential land application sites for biosolids;
- Locality-specific community opposition to land application of biosolids;
- Increased costs of utilizing land application of biosolids as a disposal strategy;
- New Florida regulations making Class B land application more difficult; and,
- Regulatory uncertainty concerning biosolids disposal over the long term.

Broward County Water and Wastewater Services (WWS) recognized these long-term biosolids challenges and reached out to all of the utilities actively engaged in processing biosolids in Broward County. WWS did so with the intent of forming a work group who would collectively explore regional solutions. The Regional Biosolids Solutions (RBS) Workgroup was formed and the members quickly agreed to perform a study. The study would help to identify viable technologies and locations for a constructable solution. Ten Interlocal Agreements were executed representing 100 percent participation. Brown and Caldwell was issued a work authorization to perform this important study.

A regional approach may offer economies of scale and resources and may achieve multi-jurisdictional public support, thereby allowing participating utilities to diversify and decrease the risk associated with management strategies. The scope of this project includes three phases – Data Development (Phase 1), Alternatives Analysis (Phase 2), and Future (Phase 3). Phases 1 and 2 are addressed in a series of workshops, attended by the RBS Workgroup participating utilities, which include Broward County Water and Wastewater Services, the City of Cooper City, the Coral Springs Improvement District, the Town of Davie, the City of Fort Lauderdale, the City of Hollywood, the City of Margate, the City of Miramar, the City of Pembroke Pines, the City of Plantation, and the City of Sunrise. The project schedule including workshop goals is shown in Table 1-1 below and the presentations from each workshop are in Attachment A.

Table 1-1. Project Workshop Schedule

Activity	Description	Date
NTP	Notice to Proceed	May 4, 2023
Workshop 1	Kickoff, Data Request	May 24, 2023
Workshop 2	Data analysis summary, Projection of Future Conditions	July 26, 2023
Workshop 3	Review of Rules and Regulations and Market Assessment	September 27, 2023
Workshop 4	High level alternatives analysis for four (4) alternatives using Solids, Water, Energy Evaluation Tool (SWEET), select two (2) for further consideration	November 1, 2023
Workshop 5	Review of two (2) alternatives, refined SWEET Model	December 13, 2023
Workshop 6	Site assessment and delivery models	February 7, 2024

Section 2: Biosolids Overview and Legislation

2.1 Biosolids Overview

Following the treatment of wastewater at domestic facilities, effluent and biosolids are left over as end products. Biosolids are primarily solid organic matter recovered from the treatment process and managed in a number of ways. A facility may choose to use or dispose of biosolids via landfill, land application, distribution and marketing as fertilizer, incineration, bioenergy or other innovative technologies, or transfer of the biosolids to another facility where one of the previous options is pursued. South Florida utilities primarily use a mix of land application and landfills to manage biosolids.

The United States Environmental Protection Agency (EPA) sets standards for biosolids beneficial use based on pathogen reduction (Class B or Class A), vector attraction reduction and pollutant concentration as well as general requirements and management practices. This EPA standard is established in Title 40 of the Federal Code of Regulations Part 503 (40 CFR 503). While this serves as the baseline, individual states may promulgate regulations that take into consideration additional state specific considerations. Florida-specific regulations will be discussed throughout the document, but relevant to biosolids classification is an additional tier or classification, Class AA. Chapter 62-640 of the Florida Administrative Code adopts and incorporates requirements from 40 CFR 503 in regard to pathogen reduction, vector attraction reduction, monitoring, laboratory testing, and annual reporting.

2.1.1 Unclassified Biosolids

Unclassified biosolids are not allowed to be used for "beneficial use" meaning they do not meet the federal and state requirements that qualify them to be utilized in any way other than by hauling to a landfill for final disposal or to an alternative treatment facility to be converted to Class B or A/AA.

2.1.2 Class B Biosolids

The "Class B" designation for biosolids means that the biosolids meet the Class B pathogen reduction requirements, vector attraction reduction requirements, and pollutant concentrations of the Florida Administrative Code (FAC). The specific quantities of allowable pathogens and other concentrations are listed in Code of Federal Regulations Title 40 Part 503 and are referenced in the FAC. Class B biosolids in Florida are typically used for land application on permitted sites or hauled to other facilities for additional treatment to Class AA (Truitt, 2019). Pathogens may still exist in Class B biosolids, which is why the EPA has set restrictions that allow time for pathogen degradation before land application for harvesting crops and turf, grazing animals, and public contact. Class B biosolids that are to be land applied in the state of Florida require a Nutrient Management Plan (NMP). NMPs are a site-specific plan, developed in accordance with the FAC and approved by the Florida Department of Environmental Protection (FDEP), establishing the rate at which all biosolids, soil amendments, and sources of nutrients can be applied to the land for crop production while minimizing the amount of pollutants and nutrients discharged to waters of the state.

2.1.3 Class A / Class AA Biosolids

The "Class AA" designation for biosolids means that the biosolids meet the EPA's federal Class A pathogen reduction requirements and vector attraction reduction requirements, and that the pollutant (e.g. heavy metals) concentrations of the FAC (Hallas et al., 2019) are also met. It should be noted that Class AA and Class A designations are used commonly in Florida, but Class AA is not used elsewhere in the US. The goal of Class A standards is to reduce pathogens below detectable limits and are therefore stricter than the Class B standards. Class AA biosolids in Florida are able to be distributed and marketed like other commercial fertilizers (Resek, 2021). Class AA biosolids do not require an NMP if they are marketed or distributed as fertilizer but they then will fall under additional regulations associated with the Florida Department of Agriculture and Consumer Services.

2.2 Rules and Regulations

The rules and regulations surrounding biosolids were presented to the group during Workshop 3 and are summarized in the following subsections.

2.2.1 Title 40 Code of Federal Regulations (CFR) Part 503

As a part of the Clean Water Act Amendments of 1987, the US EPA developed a new regulation to protect public health and the environment from the negative effects of pollutants and pathogens that can be present in biosolids (Walker et al., 1994). This regulation, named *The Standards for the Use or Disposal of Sewage Sludge*, is Title 40 of the Code of Federal Regulations, Part 503, and was promulgated in 1993. It is commonly referred to as simply "Part 503". Part 503 is a self-implementing rule meaning that the requirements must be met even if a permit has not been issued (*Biosolids Laws and Regulations*, 2023). An enforcement action can be taken against a Wastewater Treatment Plant (WWTP) that does not meet the requirements of Part 503 even if there is no issued permit for the use or disposal of sewage sludge. Treatment facilities that are specified in Part 503 are required to submit annual reports on biosolids treatment and management practices by February 19th of each year.

2.2.2 Chapter 62-640 of the Florida Administrative Code

Chapter 62-640 is the chapter of the FAC that pertains to biosolids and is primarily based on Part 503. The purpose of this chapter, first published under a different chapter heading in August 1990 and then amended in 1998, 2012, and again in 2021, is to mitigate the threat that unregulated use, disposal, or land application of biosolids can pose to the environment and public health (Barker, 2021). Beneficial use of biosolids is encouraged and minimum requirements for treatment and management of biosolids applied to land as well as distributed and marketed are established. This chapter applies to domestic wastewater treatment facilities, biosolids management facilities, distributors of biosolids or biosolids products, application sites which receive biosolids, septage management facilities that apply septage to sites, appliers of septage owners of application sites, and composting facilities that apply the compost to land (*DEP Chapter 62-640, F.A.C., Rulemaking*, 2023). This chapter does not apply to the treatment, management, or disposal of sludge, septage, or residuals that result from the industrial wastewater treatment process. In addition, this chapter addresses the disposal of biosolids by landfill, monofil, surface impoundment, waste piling, incineration, co-composting with yard or bulking waste, and blending.

Chapter 62-640 provides additional requirements for the land application of Class B and AA biosolids. These requirements apply primarily to, but not limited to, storage of biosolids at land application sites, cumulative application limits, setback distances, pH, soil depth, and runoff prevention measures.

2.2.3 Florida Statute 403.0855 (effective July 2020, compliance by July 2022)

Effective July 1, 2020, permitted land application sites for biosolids must comply with two provisions listed in Section 403.0855 of the Florida Statutes. The first requires that the permittee of a biosolids land application site shall be enrolled in the Florida Department of Agriculture and Consumer Services Best Management Practices program. The next requirement is that the permittee of a biosolids land application site shall ensure a minimum unsaturated soil depth of 2 feet between the depth of biosolids placement and the water table level at the time the Class A/AA or Class B biosolids are applied to the soil. This statute does not allow for biosolids to be applied on soils that have a seasonal high water table less than 6 inches from the soil surface or within 6 inches of the intended depth of biosolids placement. The only exception is if the permittee obtains department-approved nutrient management plan and water quality monitoring plan that provides reasonable assurances that the land application of biosolids at the site will not cause or contribute to a violation of the state's surface water quality standards or groundwater standards. All permits were required to comply with these requirements by July 1, 2022.

2.2.4 House Bill 1309 (effective June 2021)

The newest amendments to Chapter 62-640 were proposed as a part of House Bill 1309. This bill was signed into law on June 21, 2021, ratifying the proposed biosolids rules. Based on Section 403.0855 of the Florida Statute, and the deliberations of the now disbanded Biosolids Technical Advisory Committee, the rule revisions were developed to minimize the migration of nutrients, specifically phosphorus, to prevent impairment to waterbodies.

The following sections include a summary of key revisions made to Chapter 62-640 that affect biosolids disposal and land application.

2.2.4.1 Scope, Intent Purpose, and Applicability (62-640.100, FAC.)

These changes established the compliance period for existing facilities and land application sites. All permits for facilities and biosolids land application sites were required to meet the new requirements within two years of the effective date of the new rule. In other words, by June 2023.

2.2.4.2 Nutrient Management Plan (62-640.500, FAC.)

This section contained many of the largest key revisions to the rule. Land applied biosolids are, under 40 CFR 503, applied in accordance with an agronomic rate calculated based upon the nitrogen content of the biosolids and typical plant uptake rates. The revisions described in this section adjust both the nitrogen based agronomic rate as well as requiring utilities to consider phosphorus in determining land application rates. Under the revised rule, the biosolids application rate is limited to the more restrictive of the two nutrient (nitrogen or phosphorus) based rates. The only exception is if the applicant can demonstrate the site has native phosphatic soils. In most cases in Florida, this means that application limits will be based on phosphorous. Another change involved the addition of a table that displays the allowed minimum crop nutrient needs (nitrogen and phosphorous). In addition, this section required that soil phosphorus storage "capacity index", soil phosphorus results from the most recent annual soil fertility testing for each application zone, and percent water extractable phosphorus of each biosolids source be included in the NMP. Prior to this rule change, the total nitrogen allowable was calculated using what was referred to as the "EPA Method" and was two times the Plant Available Nitrogen (PAN). Now, nitrogen application rates are 1.5 times the PAN per acre per year. Finally, the update specifies that the NMP be reviewed annually with the annual soil fertility results (previously done every permit term of 5 or 10 years) and revised for the upcoming year. The overall implication of these changes are significantly reduced land application rates for most utilities.

2.2.4.3 Pathogen Reduction and Vector Attraction Reduction (62-640.600, FAC.)

This update eliminated a previous provision allowing septage to meet Class B pathogen reduction treatment by raising the pH to 12.5 for 30 minutes because it is not possible for lime to reach a pH over 12.47 at a temperature of 25 degrees Celsius. Now, this section states that septage management facilities that are regulated by the FDEP, and that do not treat any amount of biosolids, satisfy Class B pathogen reduction requirements if enough lime is added to produce a pH of 12 for a minimum of two hours.

2.2.4.4 Monitoring, Record Keeping, Reporting, and Notification (62-640.650, FAC.)

Similar to Section 62-640.500, there were many far-reaching changes made to this section. Now, it is required that treatment facilities monitor for water extractable phosphorous immediately following the effective date of the rule. Water extractable phosphorus was also added to the list of parameters to be analyzed in biosolids during routine monitoring for treatment facilities. All soil fertility testing must be equivalent to the “Phosphorus Index Test” as conducted by the University of Florida Institute of Food and Agricultural Sciences Extension Soil Testing Laboratory. Soil fertility testing samples used for capacity index may be deeper than 6-inches but cannot be from below the seasonal high-water table. This section’s updates also revised the requirement for groundwater monitoring to a lower nitrogen threshold and established a phosphorous threshold. If the soil capacity index becomes negative, permittees are now required to submit a ground water monitoring plan. Also, surface water monitoring requirements were established based on the proximity of the application area to surface water. Surface water monitoring is now required in site record keeping.

2.2.5 Per- and Polyfluoroalkyl Substances (PFAS) Regulations

Per- and polyfluoroalkyl substances (PFAS) are a large group of synthetic chemicals used in various products, including firefighting foams, cookware, food packaging, and stain repellants. Two of the most-studied members of this chemical group are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). Scientific studies indicate that these chemicals can accumulate in the body and lead to various adverse health effects in animals and humans. Potential adverse human health effects include increased cholesterol levels, low infant birth weights, immunological effects, cancer, and thyroid hormone disruption. Due to its impacts, the EPA is currently performing a risk assessment of PFAS pathways into the human body, including via biosolids land application. Pre-emptively, biosolids land application has been stopped in some locations, nearly all in locations with legacy industrial use of PFAS (e.g., paper mills, metal finishers) due to concerns of PFAS.

Although PFOA and PFOS have been voluntarily phased out by most US industries, they persist in the environment. In addition, there are thousands of other PFAS still in use for which little information is available regarding environmental occurrence or toxicity. As of this writing, there are approved analytical methods to analyze 29 compounds in drinking water. EPA method (1633) focuses on 40 compounds in non-drinking water media (e.g., groundwater surface water, soil, sediment, biosolids), which was recently (January 2024) released as the approved laboratory method. Otherwise, the EPA database documents upwards of 12,000 individual PFAS compounds.

In the last few years, PFAS have emerged as a top priority for research and regulatory development. PFAS are also actively studied by regulatory agencies, universities, industry, and the Water Research Foundation. Active areas of research include toxicity studies, source identification, date and transport studies, and the development of analytical methods. The EPA and some state regulatory agencies have issued guidance and regulations to protect human health and the environment from PFAS, with more regulations expected.

Risk assessments for PFOA and PFOS in biosolids are underway with expected drafts anticipated in August 2024 and finalized in December 2024. Based on current state of knowledge, it is expected that EPA will endorse source-control methods to mitigate PFAS, if necessary. Currently, Florida does not have any regulations pertaining to PFAS for wastewater and or biosolids, yet.

Section 3: Preliminary Market and Value Chain Review

The preliminary market and value chain review was presented to the participating utilities during Workshop 3 and is summarized in the following subsections.

3.1 Purpose

Brown and Caldwell performed a preliminary biosolids market and value chain review to understand the current and future biosolids market. This understanding of the regulations and their impacts on the market, in part, inform what products or beneficial reuse mechanisms are viable for Broward County, in turn, impacting the choice of biosolids treatment technologies and process. While this assessment did not provide a single ideal solution, the context gained highlights opportunities in the market for beneficial reuse of biosolids. This context is critical during the alternatives analysis and technology screening process to develop a tailored, sustainable, and effective plan.

3.2 Market Study Approach

For biosolids beneficial use, trends in the market dictate the acceptance and long-term resiliency of a given product; however, not all biosolids products are created equal. Many characteristics have impacts on market interest, including product form or quality. The greatest vulnerability of a biosolids program is the availability and sustainability of these markets. These depend on both internally controlled factors, such as the product itself and the biosolids management program, as well as external factors, such as general market pressures (e.g., cost of fertilizer, consumer perception) and the regulatory landscape. Market data collected during this assessment drove the technology alternatives examined and considered, and current market costs and trends were incorporated into Brown and Caldwell's life cycle cost analysis during the screening and evaluation process.

For the market analysis, Brown and Caldwell reviewed the current agricultural and commercial market within the Broward County area. Agricultural reuse of biosolids forms the foundation for many successful biosolids programs nationally, as it can be a way to beneficially reuse biosolids in larger amounts with multiple benefits. Agricultural markets are also willing to use a wider variety of biosolids products, including liquid and cake, compared to the commercial market. However, the economic payback for the agricultural industry is significantly different than the commercial market. The commercial market for this review is defined as businesses in the soil blending, fertilizer, and landscaping industry. Broadly speaking, the commercial market has more stringent preferences and requirements for biosolids products but can offer a higher economic return compared to the agricultural market.

3.3 Agricultural Market

Wastewater utilities have a long history of land application of biosolids for agricultural land management. Land application of biosolids is an established method of improving soil health (e.g., increasing organic matter content and water holding capacity) and providing plant nutrients. Class B biosolids are the most common product for agricultural application and can be injected as a liquid or spread as a cake using standard agricultural equipment. Agriculture-based biosolids land management programs are often the most cost-effective method of beneficial re-use; however, Class B programs are limited in market outlets (agriculture only, no public distribution) and are more at risk, from a regulatory perspective. As covered in previously, Class B biosolids face considerable application limitations in Florida. Class AA biosolids can also be applied in agricultural settings. While the economics may be significantly different than producing and land applying Class B biosolids, the differences in flexibility and state oversight between Class B and Class AA may be worth the investment.

If pursuing an agricultural land application program, Florida and the region surrounding Broward County contain a broad range of agricultural lands that could have interest in using a biosolids product. Feed, fiber, and forage are crops that have traditionally accepted biosolids. According to the 2017 Florida Census of Agriculture, 18 percent of land in Florida (1,774,357 acres) is used as for crops that fall into the categories of feed, fiber, and forage (Figure 3-1). More locally, a significant portion of the surrounding region grows crops that could use biosolids. As Broward County has a small agricultural footprint, outlets in surrounding counties were evaluated utilizing US Department of Agriculture's 2017 census data. To the north, the agricultural sector of Palm Beach County takes up 76 percent of the county, totaling around 488,000 acres. The primary crop grown is sugarcane, which is grown on more than half of the county's cropland, with 12,000 acres of sod grown. A large amount of income is produced through nursery, greenhouse, floriculture, and sod. Farms in Hendry County total around 433,000 acres, of which 47 percent is cropland and 36 percent is pastureland. The county is a top state producer of citrus, as well as beef cows. Due to the large number of livestock, hay and pasture ground are important to support the livestock industry. Collier County has a smaller, but still significant agricultural footprint, totaling around 148,000 acres. Of these acres, 56 percent are in cropland, 19 percent are pastureland, and 18 percent is woodland growing trees for harvest. Top crops include oranges and vegetables, and about $44 million (M) worth of sales are attributed to the nursery, greenhouse, floriculture, and sod industry. While not all of the acres are available for biosolids land application, it does indicate that there is potential for an agricultural land application program nearby.

As far as seasonal availability of agricultural outlets, a diversity of crop types also affords a diversity of planting and harvesting dates, around which land application would be planned. Field fertilization typically occurs before planting, though can often times be after harvest in preparation for the next crop or the next season. For certain crops, such as sugarcane and citrus, split fertilization is recommended. This provides an opportunity to fertilize the same fields multiple times throughout the year. Hay, haylage, and pasture ground tend to be flexible on fertilization schedules, but it is necessary to work with the farmer to establish when pasture rotation and hay cuttings will occur. During the rainy season, access to fields may be reduced. Additionally, biosolids land application is not allowed for growing organically certified crops; however, less than 1 percent of farms in Florida are reported to be organically certified.

These preliminary results indicate that there is a reasonable amount of agricultural acreage to support an agriculture-based biosolids management program, though additional work would be required to identify farms and develop relationships to support the program. However, managing a large Class B operation can be difficult and would require full time staff dedicated to its oversight, in addition to the permitting hurdles and strict application rules that currently exist in Florida. As Class AA is considered a fertilizer, there are separate applicable regulations, and counties can implement ordinances to limit fertilizer placement and timing. However, the counties evaluated here do not have additional fertilizer ordinances for bona fide farming operations. A Class B product is severely limited to the agricultural market, and competition for land for other purposes (e.g. real estate) can make land application more expensive. Ultimately, as was anticipated during this planning process, Class AA will offer the most flexibility in both the agricultural and commercial biosolids marketspace.

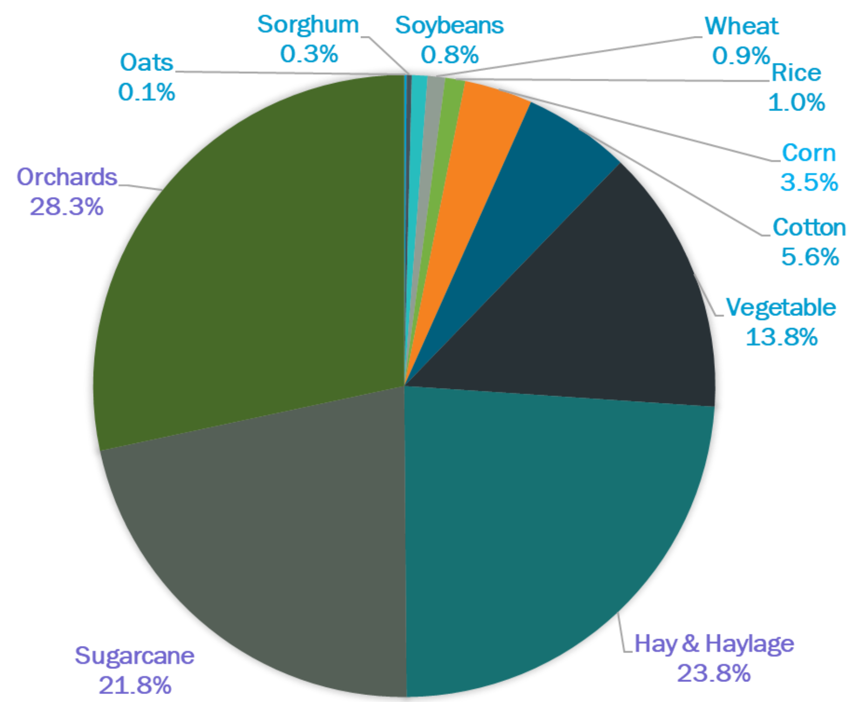


Figure 3-1. Reported acreage by crop (2017 Florida Census of Agriculture).

3.4 Commercial Market

Commercial markets, defined here as the landscape and soil blending industry, are another option for biosolids beneficial use. This market requires a Class AA product under Part 503 rules, which permits biosolids distribution to the public. Class AA biosolids can come in many forms including cake, irregular clumps, homogeneous dried pellets similar to commercial fertilizer, and compost, and the cost of producing each of these forms can vary. Because of their broader distribution ability and this range of product types, Class AA biosolids can have a more diverse set of end-use markets, which can smooth out biosolids demand throughout the year, compared to the variable annual demand of an agricultural program.

Broward County and the region surrounding, Palm Beach County and Miami-Dade County (the "Tri-county" area), contains a broad range of businesses that could have interest in using a biosolids product. To do a preliminary assessment of the commercial businesses open to using biosolids, Brown and Caldwell performed a broad biosolids market analysis. This analysis is rooted in a business survey of the region, along with guided but open-ended phone interviews with commercial end users. These interviews focused on nurseries, soil blenders, and soil distributors within a reasonable distribution distance from Broward County. These businesses have been found to be open to biosolids and a good proxy for consumer sentiment. Some entities included in the analysis have business addresses outside this "Tri-county" area, but are still within Florida and either maintain an active presence around the Tri-county or could be options in an emergency. Additionally, another market option included in this assessment were biosolids service providers and composters who could receive a Class B product for a service fee.

Producing a Class AA product and developing relationships with commercial businesses would diversify the program, protect against potential threats to Class B land application, and provide an opportunity to smooth out seasonal demand for biosolids. Following these conversations, Brown and Caldwell found that there is a viable market for Class AA biosolids products among commercial businesses or viable options for third-party handoff of Class B biosolids.

3.4.1 Market Assessment Methodology

A market survey was conducted to identify potential commercial end users for Broward County's biosolids. The goal was to understand what market type was available, should Broward County decide to pursue a Class AA product. A 10-question survey was created and used to guide conversations. The intention of the survey was to understand interest, volume, seasonal demand, and expected costs. A tri-county search for potential commercial end users was performed and included national and regional biosolids service providers. Biosolids markets are limited to those that are outside of organic-certified farming, but some organic distributors were contacted to gain a general understanding of the perception of biosolids land application. Contact information for end-users was obtained using internet searches, and surveys were completed via phone interviews. Summaries and key takeaways are presented below.

3.4.1.1 Potential End-users Identified

There were 41 businesses and 6 extension agents included in this survey. All businesses that were identified and called were located within Florida, with the majority located in and around Broward County area. Those surveyed consisted of the following business types:

- Soil blenders, fertilizer blenders, and landscape suppliers that blend raw materials as their own topsoil and mixes, then sell them to customers (e.g., farmers, contractors, landscape suppliers, etc.)
- Landscape suppliers who buy pre-mixed blends and sell landscape materials through wholesale or retail

Overall, Figure 3-2 demonstrates a very active landscaping industry in the region surrounding Broward County, significantly more than other regions with active commercial biosolids programs and shows promise for a commercial program, either managed internally or contracted to a third-party. Figure 3-3 depicts the 9 businesses that were interviewed. The phone number for the one business that completed a survey, but is not depicted in Figure 3-3, was a corporate phone number.

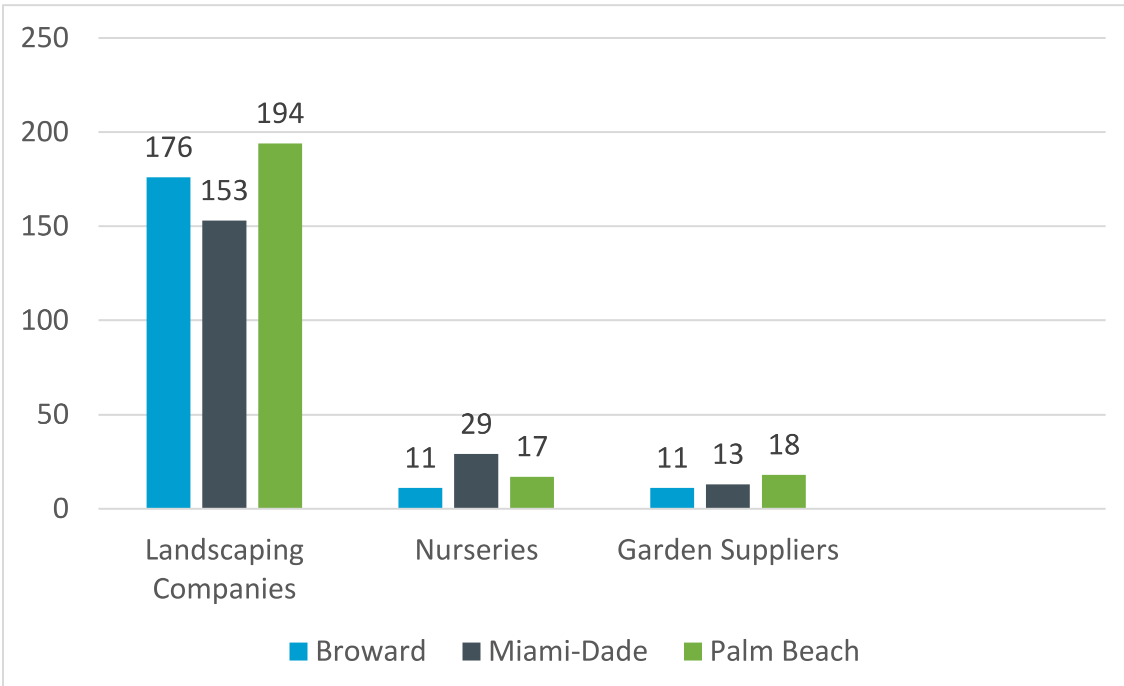


Figure 3-2. Survey of relevant commercial businesses in the Tri-county area.

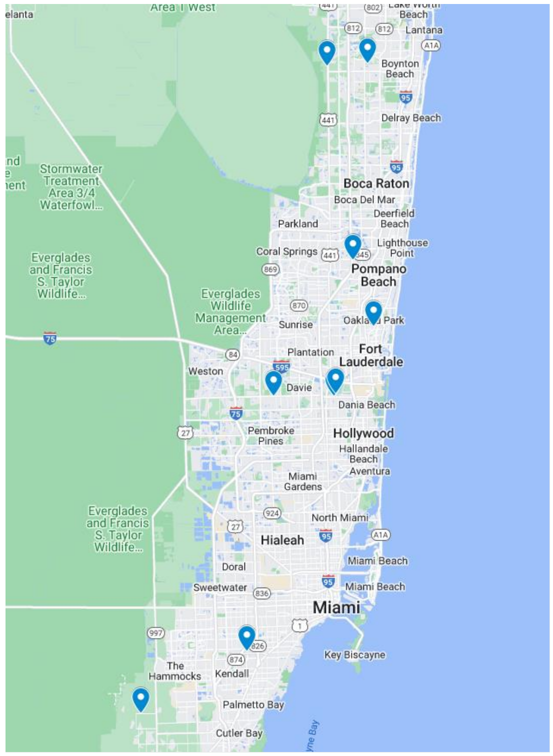


Figure 3-3. Location of the 9 businesses interviewed.

3.4.2 Survey Response Rate

General responses for all end users (i.e., surveyed businesses) called are presented in Table 3-1. From the total general responses, 13 entities were reached via phone and none declined to participate. A total of 10 successful interviews were conducted, with over 90 percent of interviewees within the Tri-county area.

Table 3-1. General Summary of Commercial Calls

Response	Number of Businesses
Contacted, No response	29
Contacted, Declined survey	0
Completed Survey	10
Incomplete Survey	2
Total Contacts	41

3.4.3 Impressions

A rating process was used to categorize participant's general impressions of biosolids. Only biosolids service providers, who typically perform Class B land application, were interviewed about Class B cake. All other end users were interviewed regarding Class A products. Four categories were identified:

- A positive (+) rating, where the user is familiar with biosolids and would promote its usage.

- A neutral (+/-) rating, where the end user likes the benefits and/or results from the product, but dislikes some aspects, i.e., thought of biosolids from human waste, odors, etc.
- A negative (-) rating, where the end user dislikes the product completely and will not use it.
- Not familiar with biosolids; the end user has not heard of the product or related terminology (e.g., sewage sludge, sludge, etc.) or not interested in biosolids; the end user expresses they are not interested in biosolids, either providing or not providing a reason.

Table 3-2 presents the number of end users surveyed and their responses. Overall, 3 out of 10 end-users surveyed had a positive impression of biosolids, 3 had a neutral impression, one had a negative impression, and 3 did not know what biosolids were or were uninterested.

Table 3-2. General Impressions from Surveyed Contacts

Response	Number of Businesses
Positive (+)	3
Neutral (+/-)	3
Not familiar	3
Negative (-)	1

Landscape companies, plant nurseries, and garden suppliers are known to carry a wide assortment of fertilizers, soil amendments and compost that is sold to the public. Tapping into regional markets allow a chance to focus on individual consumers and promote year-round consumer demand for biosolids. These would include contractors, other businesses, and individual consumers. Commercial customers could only accept Class AA biosolids and would require Broward County to invest in additional biosolids processing compared to the existing program. Additionally, the development of such an end-use market would require upfront operational investment to identify businesses and develop relationships.

Generally, these businesses are busiest during the winter and spring, as consumers are preparing for the summer season. Landscape companies, plant nurseries, and garden suppliers are known to carry a wide assortment of fertilizers, soil amendments and compost that is sold to the public. Tapping into regional markets allow a chance to focus on individual consumers and promote year-round consumer demand for biosolids. Overall impressions of biosolids were mixed among commercial businesses, with many contacts mentioning customer concerns and the need for public education and strong marketing. While businesses we spoke to understand the nutritional and environmental benefits of biosolids, they were concerned that their customers may have concerns about using human waste. Additionally, one contact mentioned that they wouldn't recommend it to customers for growing food, though another contact spoke highly of biosolids as a "non-burning" soil amendment, which can occur with conventional ammonia-based fertilizers. If a Class AA product is produced and a commercial market is sought, in-person visits to discuss these concerns and to provide samples of the product would be beneficial to mitigate these responses and educate customers. If Broward County chose to produce a Class AA product, additional opportunities for community outreach is recommended.

3.4.3.1 Additional Markets

The Broward County golf market is another option for biosolids beneficial use; Figure 3-4 depicts the 35 golf courses within the County. Granular or dry fertilizers are commonly used in maintaining a golf course. In some cases, high concentrations of iron found in biosolids can lead to brighter golf greens, which is highly desirable. While a uniform pellet fertilizer is preferred, additionally, golf course require small pellet sizes, often smaller than standard biosolids pellets ("greens grade"), to work with grass-cutting operations. Milorganite®, a nationally known biosolids product, specifically produces a greens-grade product to meet this market. The financial implications of any additional markets should be evaluated and considered as a part of future steps.

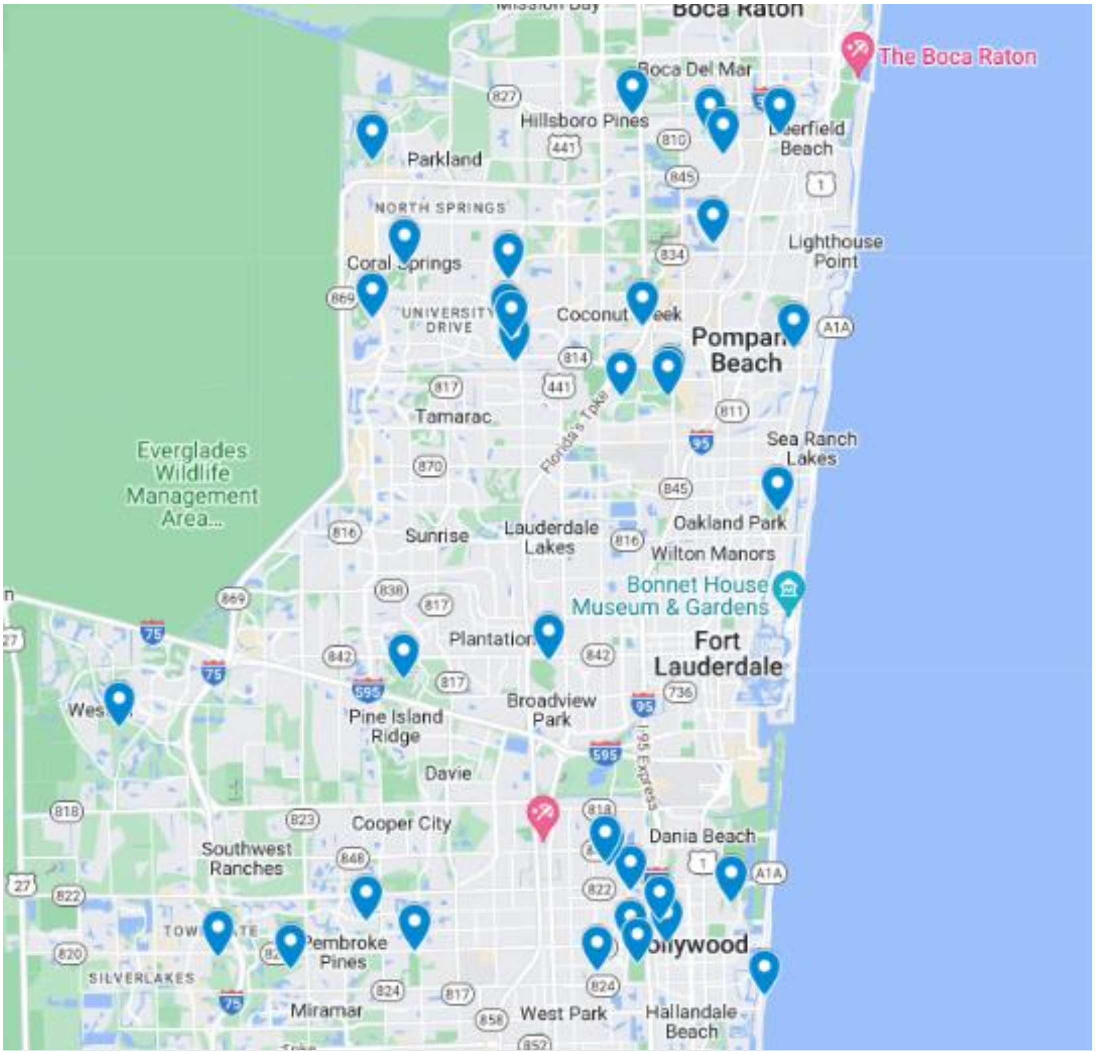


Figure 3-4. Location of golf courses.

3.5 Market Takeaways

From this preliminary market assessment, the agricultural demographic survey indicates enough acreage to support a biosolids product from Broward County, though additional discussions with farmers and biosolids land appliers in the region would help clarify the pressures from real estate and other drivers. The strong presence of landscape businesses in the region indicate a larger pool of possible customers and outlets, though significant marketing and consumer education would be beneficial in developing this market. Partnerships with state extension agents, the University of Florida Institute of Food and Agricultural Sciences, or master gardener programs have been found to be helpful in other regions.

Section 4: Evaluation of Existing and Future Conditions and Utilities

4.1 Practices by Neighboring Utilities

When determining what is most practical in Broward County, it is important to look to neighboring communities and see which practices are working, or not working, in those geographies. The four neighboring communities that were analyzed were Miami-Dade County, Palm Beach County, St. Lucie County, and the City of Hollywood. It is important to note that, while Hollywood is within Broward County, they are the only city treating to Class AA biosolids on site and the team felt that it was important to better understand why and how this works.

In Miami-Dade County, there are three wastewater treatment plants – the North District (ND), Central District (CD), and South District (SD) Wastewater Treatment Plants. ND doesn't have their own on-site biosolids and they instead pump their sludge to CD. There, the CD waste sludge and ND transfer sludge is thickened and then anaerobically digested to a Class B biosolids end product. SD also produces Class B dewatered biosolids. Then, haulers from H&H and Revinu are contracted to haul the Class B product from each site to permitted land application sites such as Deseret Ranch in St. Cloud, FL. The largest concern that Miami-Dade County has is that increased legislation has made it more difficult to find a permitted site for Class B land application and thus their costs are increasing.

In Palm Beach County, municipalities are able to bring their unclassified biosolids to a Synagro (formerly NEFCO) dryer facility that has been online since 2009 at the Solid Waste Authority. Each of the six partnering communities is allocated a portion of the 600 wet ton per day design capacity of the facility. The dryer itself is powered by natural gas and then the dried product pelletized and sold as a fertilizer amendment. An issue that the Palm Beach County staff expressed was that maintaining the facility is expensive and, while every partner pays the same per tonnage, some sludge is coming into the facility much wetter than others which is more energy intensive for the dryer to get to a Class AA product. The Palm Beach County dryer facilities were toured by many of this project's participating utilities and members of our team on January 19, 2024.

St. Lucie County is made up of a large City of Port St. Lucie wastewater treatment plant and a couple of smaller wastewater facilities. All of the facilities dewater their sludge, but do not further treat the biosolids. Instead, they have hauling contracts with Synagro to haul their biosolids to the Compost USA composting facility in Venus, FL. St. Lucie County has also seen increased landfill prices, which is an area of concern because they previously considered that as a viable option for their unclassified biosolids.

The City of Hollywood in Broward County is unique because they use a Schwing Bioset lime softening unit and increased temperatures to treat their biosolids to Class AA on site. Their Class AA end product is hauled by Revinu to be used as fertilizer at ranches in Venus, Highlands County, and Glades County, FL. Hollywood has expressed that their Schwing Bioset equipment is challenging to operate and maintain, so continuing to produce Class AA biosolids can often be difficult.

4.2 Existing Biosolids Quantities and Characteristics in Broward

In May 2023, all RBS Workgroup members that produce biosolids were sent a request for data in order to determine their current biosolids quantity, characteristics, and associated prices. The requested questionnaire included:

1. Any summary or planning document that provides an overview of the current solids' operation and/or plans for future investments.

2. Three years' worth of sludge/biosolids operation (from raw sludge production in primaries or activated sludge, through thickening, other-processing, dewatering, and trucks being "sent out the door"); and any/all related laboratory data.
   a. Those facilities that do not regularly collect total solids (TS) or volatile solids (VS) data, were requested to collect and test at least three samples of each sludge along the process train and analyze for TS and VS.
3. Their most recent fully completed fiscal year of budgeted and performance-against-budget for solids-related costs. This should include, thickening, dewatering, or other process operations and maintenance (O&M), polymer, or other chemical additional/use, and contracted services (likely for hauling/disposition).
4. Assessment (even if a current guess) as to the useful life of any process unit equipment, tankage, or other infrastructure that is needed for solids treatment.
   a. For utilities that had Capital Improvements planned and budgeted, please share estimated costs and descriptions for those.
5. Summary of power-cost rate structure and current power unit costs, as well as an estimate of average power use for solids handling.
6. If natural gas or other fuels are used for solids handling, please provide your average unit costs and usage.
7. Other pertinent/related information for consideration.

Data was received from all 11 utilities that were sent requests and were then compiled into a current data summary of wet and dry tons of solids per day, percent solids, hauling fee, and stabilization process. The results are in Table 4-1.

Table 4-1. Current RBS Workgroup Facilities Data							
Region	Current Data Summary (average 2020-2022)				Projected Data (2043)		Additional Stabilization Treatment
	Wet Solids (wtpy)	Dry Solids (dtpy)	% TS	Hauling & Tip fee ($/wt)	Wet Solids (wtpy)	Dry Solids (dtpy)	
Broward County	94,911	14,833	15.63%	$44.48	103,660	16,200	Anaerobic Digestion
Cooper City	3,668	491	13.40%	$37.90	3,730	500	Aerobic digestion
Coral Springs Improvement District	2,546	308	12.10%	$64.00	2,810	340	Aerobic digestion
Town of Davie - System II	2,697	337	12.48%	$55.47	3,040	380	Aerobic digestion
Town of Davie - System IV	992	110	11.05%	$55.47	1,090	120	Aerobic digestion
Fort Lauderdale	29,457	5,150	17.48%	$63.36	36,550	6,390	Aerobic digestion
Hollywood	65,179	6,909	10.60%	--	74,620	7,910	Lime stabilization
City of Margate	4,016	657	16.37%	--	4,640	760	Rotating Biological Contactors
City of Miramar	14,130	1,707	12.08%	$37.90	15,480	1,870	Anaerobic Digestion
Pembroke Pines	3,028	485	16.00%	$58.41	3,190	510	Aerobic digestion
Plantation	1,051	129	12.24%	--	1,230	150	Anaerobic Digestion
City of Sunrise - Sawgrass	10,050	1,811	18.02%	$61.43	10,710	1,930	Aerated sludge holding tanks
City of Sunrise - Springtree	3,470	680	19.59%	$61.32	3,680	720	Aerated sludge holding tanks
Total	235,195	33,606	14.29%	$50.82	264,430	37,780	

(wtpy = wet tons per year, dtpy = dry tons per year, $/wt = cost per wet tons)

4.3 Biosolids Forecast

Once the current data summary was developed, the data was projected out to the year 2045. Population data came from the 2020 US Census and The Broward County and Municipal Population Forecast and Allocation Model (PFAM) prepared by the University of Florida Bureau of Economic and Business Research (BEBR). A model was developed using Census data that was then normalized by applying the percentage difference between the PFAM's 2020 population data to US 2020 Census data for each municipality. The calculated percentage difference for each municipality was applied to their respective populations through 2045.

This model assumed that the biosolids management service area for each town or city was similar to the municipal jurisdiction. Because Broward Municipal Services District (BMSC) is not a city or a town, there was no Census 2020 data with which to compare the population projections. The percentage difference between the PFAM's data and the 2020 Census data of 1.6 percent was applied to BMSC's 2017 projected population. This means, the assumption that the differences in population projections in BEBR's model for Broward County and BMSC were assumed to be similar when comparing to US 2020 Census.

The population projections were used to calculate a percent change for each year for each jurisdiction. This annual change percentage was used for dry solids production and therefore the total dry solids number for 2043, the forecast year for design. Percent total solids (TS) was kept consistent from the current data and this was used to calculate the wet solids. The final projected data can be seen in Table 4-1 on the previous page.

Section 5: Technology Alternatives Analysis

5.1 Universe of Options

A comprehensive list of biosolids technologies (as detailed in Attachment B) was developed and shared with the RBS Workgroup during Workshop 2. The comprehensive list of technologies is referred to as the "universe of options", as seen in Figure 5-1 below. The technologies available were classified as either pretreatment, anaerobic digestion, composting, drying, chemical stabilization, high temperature, and lagoons. Technology status was defined as follows using the following definitions:

- **Embryonic:** The embryonic status represents technology in its early development state that has been demonstrated at bench or small-pilot scale. In many cases, the technology may not have been proven or operated at full scale with biosolids.
- **Innovative**: Technology categorized as innovative or emerging are commercially viable and have been proven at full scale in one or more installations. Innovative or emerging technologies have a shorter track record than established technologies (typically less than 5 years), and O&M costs are inherently less well known as a result.
- **Established:** This category includes technology well established in the industry for solids processing applications. These technologies have been implemented and operated at full scale for a minimum of 10 years.

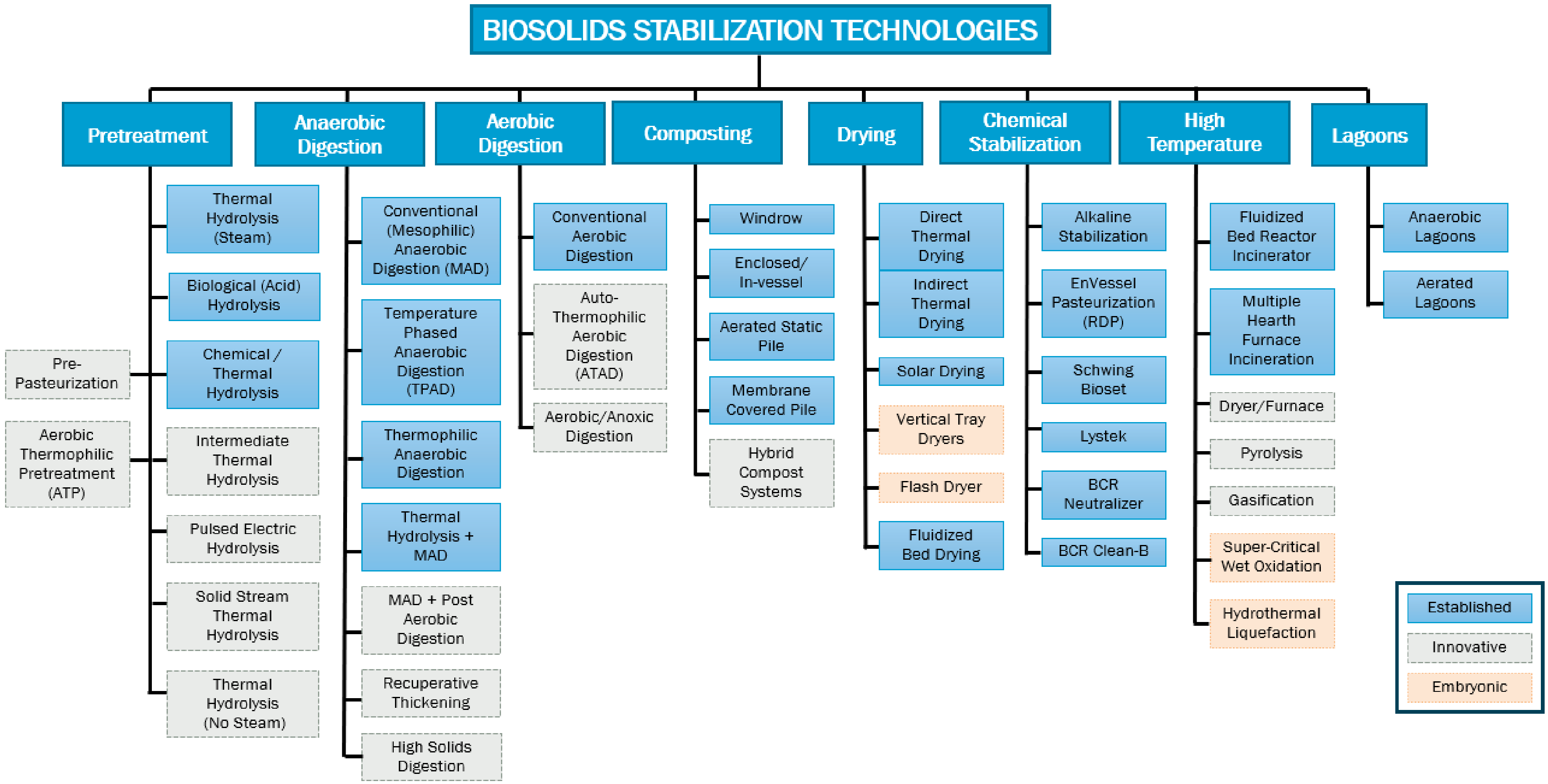


Figure 5-1. Universe of options for biosolids stabilization technologies.

5.2 Pass/Fail Assessment

The technologies were screened using a pass/fail criteria assessment. Based upon input from the participating agencies, the screening criteria eliminated embryonic and antiquated technologies, technologies that could only produce Class B biosolids as an end product, and technologies that do not accept dewatered solids, as these would not meet the goals of this planning study, as shown in Figure 5-2 below.

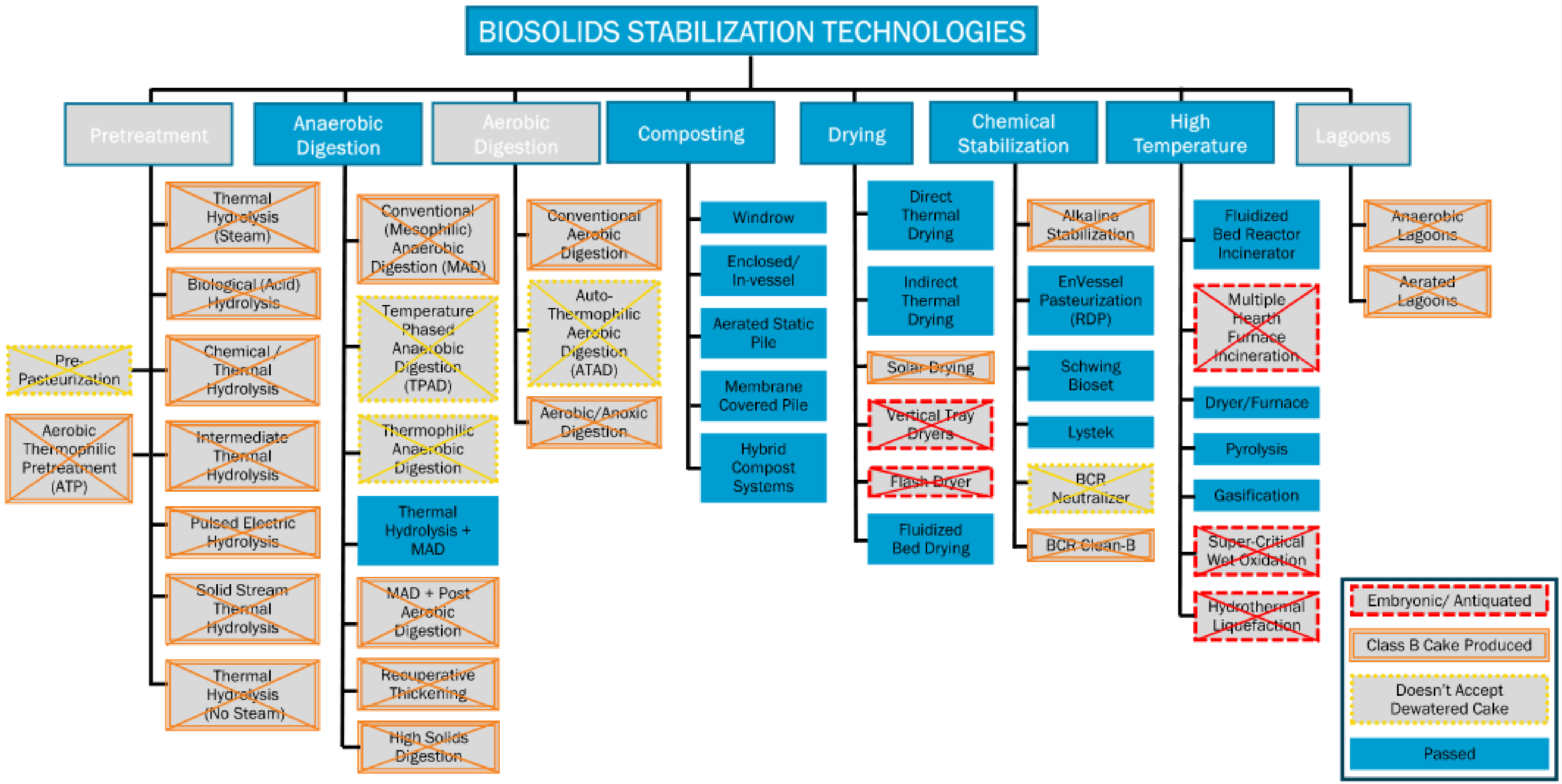


Figure 5-2. Universe of options and elimination criteria.

5.2.1 Analysis of Technologies Surviving the Pass/Fail Assessment

Following Brown and Caldwell's pass/fail assessment, representative technologies were chosen for each remaining categories and moved on to the next set of elimination criteria. The remaining technologies at this point in the process were:

- Thermal Hydrolysis (THP) with Mesophilic Digestion (anaerobic digestion)
- Composting
- Thermal Drying
- Schwing Bioset (Chemical Stabilization)
- Pyrolysis (Thermal Process)
- Lystek (Chemical Stabilization)
- Fluidized Bed Incinerator (High temperature)

During discussions regarding the above list during Workshop 2, one of the utility representatives proposed that solar drying be reintroduced to the final technologies list. Solar drying was eliminated during the pass/fail assessment because it typically is only able to produce a Class B final product. However, it was added back to the technologies list because discussions concluded that it can be used in combination with other technologies to produce Class AA biosolids.

5.3 Non-Cost Goals and Objectives

Brown and Caldwell developed a list of goals and objectives for a regional facility that focused on criteria other than economics. The proposed non-cost goals and objectives are as follows:

A. Create a diversity in biosolids/residue end use markets (Class AA product)

B. Reduce biosolids volume

C. Beneficially reuse biosolids and allow for resource recovery

D. Provide flexibility and scalability to meet future regulations

E. Ease of operation and maintenance

F. Maintain or improve current carbon footprint

G. Proven technology

H. Minimizes footprint requirements to achieve objectives

I. Minimizes neighborhood impacts (odors and traffic)

Discussions with the utilities present at the workshop amended item G to include that the technology must be reliable in addition to proven. Also, the following goals were added to the list based on feedback from the group:

J. Reduced regulatory oversight/paperwork

K. Redundancy

L. Permittable (including length of permitting time and ability to make it through a public hearing)

5.4 Goals Scoring and Results

Once the finalized list of goals was agreed upon, the workshop attendees broke out into groups and ranked the importance of the goals on a scale from 1 (less important) to 3 (most important). One score sheet was submitted per utility in attendance. The results are summarized in Table 5-1 below.

Table 5-1. Criterion Ranking/Weighting by Each Utility

Criteria	Utility 1	Utility 2	Utility 3	Utility 4	Utility 5	Utility 6	Utility 7	Utility 8	Utility 9	Avg.
Create A Diversity In Biosolids/Residue End Use Markets (Class AA Product)	2	2	3	3	3	3	3	3	3	**2.78**
Reduce Biosolids Volume	2	1	2	2	2	2	3	3	3	**2.22**
Beneficially Reuse Biosolids And Allow For Resource Recovery	3	3	3	3	3	3	3	3	2	**2.89**
Provide Flexibility And Scalability To Meet Future Regulations	3	3	3	3	3	1	3	3	3	**2.78**
Ease Of Operation And Maintenance	3	2	3	3	2	2	3	2	2	**2.44**
Maintain Or Improve Current Carbon Footprint	2	3	3	3	3	1	3	2	2	**2.44**
Proven Technology	3	3	3	3	3	3	3	3	3	**3.00**
Minimizes Footprint Requirements To Achieve Objectives	1	1	2	2	2	2	3	2	2	**1.89**
Minimizes Neighborhood Impacts (Odors And Traffic)	3	3	2	3	3	2	1	2	2	**2.33**
Reduced Regulatory Oversight/Paperwork	2	3	1	1	2	1	3	3	3	**2.11**
Redundancy	3	3	3	3	3	3	3	3	3	**3.00**
Permittable (Including Length Of Permitting Time)	3	3	3	3	3	1	3	3	3	**2.78**

5.5 Technology Scoring Based on Goals and Objectives

The technologies that remained after the pass/fail assessment was scored by the Brown and Caldwell team was based on that technology's ability to meet the criteria. Each technology was scored from 0-5 where a score of 1 indicated that the technology did not meet the criteria and a score of 5 indicated that the technology perfectly meets the criteria. These results are in Table 5-2 on the following page. The scores indicated in in Table 5-2 are based on Brown and Caldwell's engineering experience as well as typical projects. For instance, thermal dryers received a score of 2 for redundancy. Historically, WWTPs would not install a redundant thermal dryer due to cost. A thermal dryer would be sized to allow for periodic down time and or adequate storage would be added for these scheduled down times. Through Brown and Caldwell's continued work with other clients that operate thermal dryers, the thermal dryer alternative did include an additional thermal dryer for redundancy as it has been indicated that including a redundant thermal dryer is a desirable option.

Table 5-2. Technology Scores Based on Ability to Meet Criteria								
Criteria	THP + Mesophilic	Composting	Thermal Drying	Lime Stabilization (Schwing Bioset)	Thermal Process (Pyrolysis)	Chemical Stabilization (Lystek)	Fluidized Bed Incineration	Solar Drying
Create A Diversity In Biosolids/Residue End Use Markets (Class AA Product)	4	4	5	3	4	3	3	3
Reduce Biosolids Volume	3	1	4	1	4	2	5	5
Beneficially Reuse Biosolids And Allow For Resource Recovery	4	4	4	3	4	3	2	2
Provide Flexibility And Scalability To Meet Future Regulations	3	3	3	2	4	2	4	4
Ease Of Operation And Maintenance	3	4	3	3	2	4	3	3
Maintain Or Improve Current Carbon Footprint	5	3	2	2	2	2	2	2
Proven Technology	5	5	5	5	1	4	5	5
Minimizes Footprint Requirements To Achieve Objectives	3	1	3	3	3	3	3	3
Minimizes Neighborhood Impacts (Odors And Traffic)	3	1	4	2	4	2	5	5
Reduced Regulatory Oversight/Paperwork	4	4	4	4	4	4	4	4
Redundancy	4	5	2	3	2	4	2	4
Permittable (Including Length Of Permitting Time)	5	5	4	5	3	4	1	4

The next step was to assign points to each technology based on the average importance score given by all of the utilities, which can be seen in the final column of Table 5-1. Then, these averages were used to weigh the ability to meet the criteria score (Table 5-2). For example, “reduce biosolids volume” was given an average score of 2.22 out of 3 on importance as a goal when ranked by the utilities. The technology “thermal drying” received a score of 4 out of 5 in its ability to meet the goal of “reduce biosolids volume”. When each goal and technology were ranked in this way, and then the corresponding results were multiplied together, this gave a total weighted score. The results of the analysis, the total weighted scores, are in Table 5-3.

Table 5-3. Technology Options and Their Weighted Scores Based on the Above Scoring Tables	
Technologies	Total Weighted Score
THP + Mesophilic	119
Solar Drying	112
Thermal Drying	110
Composting	107
Fluidized bed incineration	98
Chemical stabilization (Lystek)	96
Lime stabilization (Schwing Bioset)	94
Thermal Process (Pyrolysis)	93

Based on the total weighted scores and group discussion, it was determined that the technologies worth moving forward were THP with Mesophilic Digestion and Thermal Drying with additional exploration of Composting, Fluidized Bed Incineration, and Solar Drying to be done in subsequent workshops.

5.6 Additional Technology Alternatives Analysis and Discussion

Following the technology scoring based on goals and objectives, the group was tasked with narrowing down the remaining five alternatives, as mentioned above, to four alternatives that would be subjected to a cost analysis. THP and Thermal Drying were officially moving on to the cost analysis phase, Section 6 below, because they received the highest total weighted scores of the proposed technologies. Solar drying required additional discussion because it was originally eliminated during the Universe of Options pass/fail assessment but was brought back based on group discussion as mentioned previously. The remaining two alternatives (composting and Fluidized Bed Incineration) received high weighted scores and it was decided during discussions that these warranted additional consideration. Brown and Caldwell presented these five technologies to the group again but provided further pros and cons to help participants come to an informed conclusion. This is summarized in Table 5-4 below. For the Composting alternative, multiple composting options and their pros and cons were presented.

Table 5-4. Additional Technology Alternatives for Discussion		
Technologies	**Pros**	**Cons**
Fluidized Bed Incineration	Produces ash Volume reduction Heat/energy can be referenced Relatively small footprint	Negative public opinion Significant and costly emissions controls Higher greenhouse gases relative to other technologies Public hearing process required to be permitted in Florida
Solar Drying	Can achieve Class AA on its own with natural gas back-up Free energy source Low installation cost Reduced handling and storage costs Low temperatures and less risk of fires and explosions No return stream of condensate Volume reduction Simple operation and low maintenance High level of redundancy	Product has a high content of pathogens, heavy metals, and organic micropollutants Sludge type influences the system Larger footprint/area availability Dependent on ambient conditions such as humidity and rain Relatively less hurricane resistant
Composting – Aerated Windrow Composting	Low initial investment Low maintenance Suitable for large volumes	Largest footprint with the addition of a bulking agent Long process time Labor intensive Odors and dust produced
Composting – Passive Aerated Static Pile Composting	Low initial investment Low to medium maintenance Not labor intensive Suitable for large volumes	Large footprint with the addition of a bulking agent Long process time Odors and dust produced
Composting – Forced Aerated Static Pile Composting	Not labor intensive Short process time Suitable for large volume generators Shorter production time (45-60 days)	High maintenance Large footprint relative to other technologies High initial investment for blowers Odors and dust produced

The workshop attendees, after analyzing the remaining options, decided to move forward to the next evaluation phase with the following alternatives: THP, Thermal Drying, Composting, and Fluidized Bed Incineration.

Section 6: SWEET Model Alternatives Analysis

6.1 Overview of the SWEET Model

This alternatives analysis utilizes Brown and Caldwell's Solids Water Energy Evaluation Tool (SWEET). This tool is used to perform energy and mass balances for a variety of technologies. SWEET modeling tracks volatile solids, inert solids, and water balances through potential process alternatives. Modeling also considers the energy required to power and heat specific processes and forecasts energy production and material recovery to estimate future demand. Brown and Caldwell's SWEET modeling can be applied to a variety of feedstocks and technologies allowing a wide range of process options to be considered. Unit costs are applied to each treatment option to estimate capital and O&M costs, thus allowing economic comparisons to be made between alternatives.

SWEET modeling estimated annual operating costs for various solids alternatives is based on average conditions, but final equipment selection, sizing, and redundancy should be confirmed during the basis of design, as well as assumptions used for annual operating costs.

6.2 SWEET Model Alternatives

This section provides detail about the alternatives approach and analysis, SWEET model assumptions, and a breakdown of project cost and economic evaluations for each alternative. The SWEET model incorporates plant hauling data and other assumptions to estimate and track volatile solids, inert solids, water flow, energy consumption, and energy recovery through each identified alternative. The model was also used to compare economic drivers such as capital and operation costs, beneficial reuse, and energy capture to rank each alternative based on a 20-year net present cost (NPC). Process sizing for all alternatives is based on current mass balance data, the proposed facility design, and assumed a regional growth projection of 1.6 percent. For sources and more details on biosolids projections, refer to Section 4.3 Biosolids Forecast.

The modeled alternatives were selected based on input from a series of workshops held with the 11 participating utilities mentioned in Section 1-1. The initial round of SWEET modeling followed Workshop 3 in which four primary alternatives were selected. Following Workshop 4, the alternatives were refined and two were eliminated. The initial round of modeling was performed for the alternatives identified in Figure 6-1.

Alt A	Thermal Hydrolysis
Alt B	Thermal Drying
Alt C	Composting
Alt D	Fluid Bed Incineration

Figure 6-1. List of initial alternatives modeled in SWEET.

In addition to the four alternatives shown above, a baseline scenario was modeled to show current and future solids loadings and costs. For more information, please reference Section 4.2 Existing Biosolids Quantities and Characteristics in Broward.

6.2.1 Alternative A: Thermal Hydrolysis

Alternative A represents a regional facility with THP. THP is an anaerobic digestion pretreatment system that enhances wastewater solids processing and energy production and can achieve Class A biosolids in certain configurations. THP utilizes medium-pressure steam to create high-temperature and high-pressure conditions, breaking down bacterial cells and solubilizing organic material in wastewater solids, thus making them more digestible. This process accelerates digestion, reduces digester residence time, increases gas production by 10 to 20 percent, lowers sludge viscosity allowing for higher solids concentrations to digestion (9 to 12 percent TS), improves dewaterability, and reduces odor generated from the digested solids. This technology was selected to be evaluated because it is a lower cost option, utilizes less land than other alternatives, and to improve potential gas capture rates. THP would be followed by mesophilic digestion, a conventional sludge stabilization process, and dewatering via belt filter press. A conceptual process diagram for Alternative A is shown in Figure 6-2. Significant capital costs associated with this alternative include the following:

- Sludge receiving station with live bottom hoppers
- Sludge storage tanks (2-day storage)
- Four THP B6.4 units (CAMBI)
- Two - 3 MG mesophilic digesters
- Digested sludge storage tank
- Belt filter press dewatering units
- Filtrate sump pumps
- Steam boiler

Alternative A provides adequate redundancy and buffer capacity for a regional approach. It also opens the option to capture and sell digester gas produced at the facility, a potential revenue stream. This approach requires approximately 4 acres of land and would require staff to learn how to operate THP, which no other utility in the area uses. Additionally, for THP to perform at its best, a higher concentration of cake is needed. The combined sludge from the existing region is at approximately 14.3 percent and the ideal feed percent TS for THP is 20 percent. The additional moisture associated with the lower percent TS means the THP units would consume significantly more energy to reduce the amount of water in the feed material. This means that more THP units and digesters would be needed for a regional facility resulting in a higher capital expense. A proposed site layout is shown in Figure 6-3. As mentioned in the Workshops and technology overview, THP's primary manufacturer is CAMBI. Currently, CAMBI has seven installations in operation and six under construction. Also, this produces a Class A liquid product that needs to be dewatered. Its primary outlet would be agricultural.

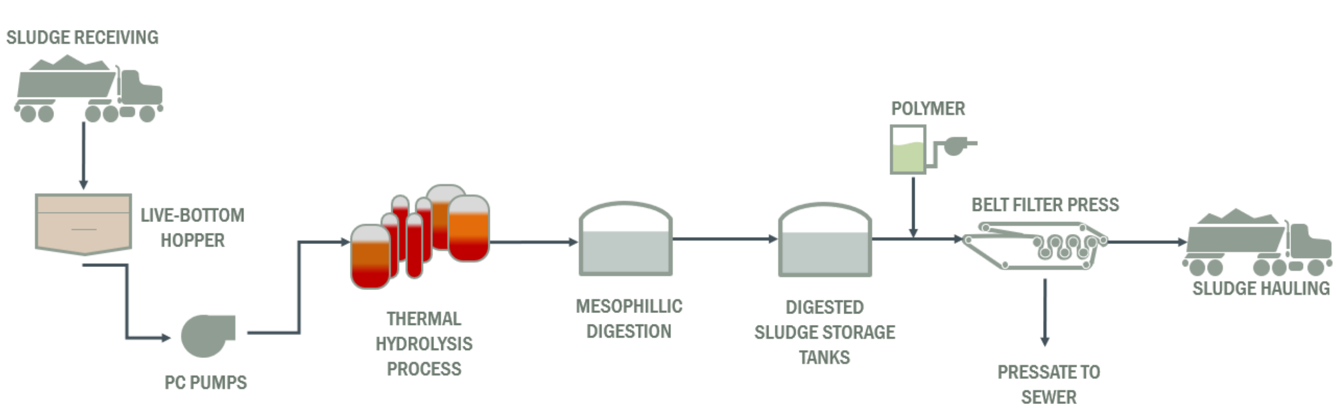


Figure 6-2. Alternative A THP process diagram.

Alternative A Assumptions:

- No major modifications would take place at any RBS Workgroup facilities
- Assumed sludge receiving and dewatering would be operated on a daily 8-hour schedule
- A minimum of 2 days of buffer storage would be required for influent sludge
- THP units sized based on 13 percent sludge feed concentration with an n+1 configuration for future sludge
- Digesters were sized using a minimum 12-day solids retention time, peak organic loading rate of 0.40 pounds VS per cubic foot-day, and with a worst-case service condition of max month loadings with one digester out of service
- Digested sludge storage of 3 days

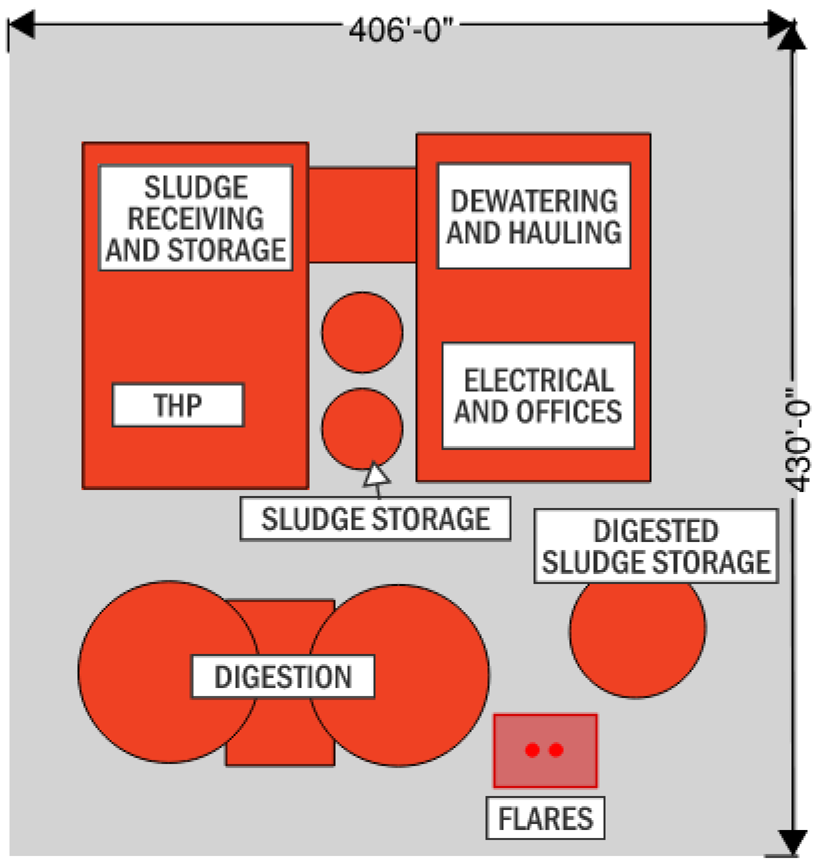


Figure 6-3. Alternative A THP conceptual layout.

Challenges with this approach:

- Boiler code operator would be required
- Side stream will require treatment
- Low percent TS concentration results in more and larger THP units
- High operational complexity associated with THP

6.2.2 Alternative B: Thermal Drying

Alternative B represents a regional facility using thermal dryers. Thermal drying produces a dried product that can be used in a variety of end-use markets. This technology was selected because it is a well-known technology within the industry, it produces a Class AA biosolids product, has a relatively compact footprint, and reduces volume of the end-product. Additionally, with the regional facility receiving a combination of aerobically and anaerobically processed sludge, the thermal drying approach does not require additional digestion. This process involves two sludge receiving stations, screw conveyors, thermal drying systems, followed by pellet storage and hauling. The footprint for the thermal dryers was based on drum drying technology from Andritz, which is commonly used in large installations, but can be modified for any thermal drying vendor. A conceptual process diagram for Alternative B is shown in Figure 6-4. Significant capital costs associated with this alternative include the following:

- Sludge receiving station with live bottom hoppers
- Sludge conveyance
- Four – Drum Dryer System (DDS) 110 Thermal Dryers
- Four regenerative thermal oxidizer (RTO) systems for odor control
- Five pellet silos

Alternative B provides adequate redundancy and buffer capacity for a regional approach. This approach requires approximately 5 acres of land and would require staff to learn how to operate thermal drying systems. Similar to the challenge with THP, for thermal drying to perform at its best, a higher concentration of cake is needed. The combined sludge from the existing region is at approximately 14.3 percent and the ideal feed percent TS for drum dryer assumed is 20-26 percent. When the moisture content is too high, thermal drying consumes significantly more natural gas to reduce the amount of water in the material. This means that more or larger DDS units would be required for a regional facility resulting in a higher capital expense. A proposed site layout is shown in Figure 6-5. As mentioned in the Workshops and technology overview, there are several thermal drying manufacturers and dryer types. Hundreds of thermal dryers have been in operation in the wastewater industry since the early 1950s. Each dryer type has their own list of benefits and challenges.

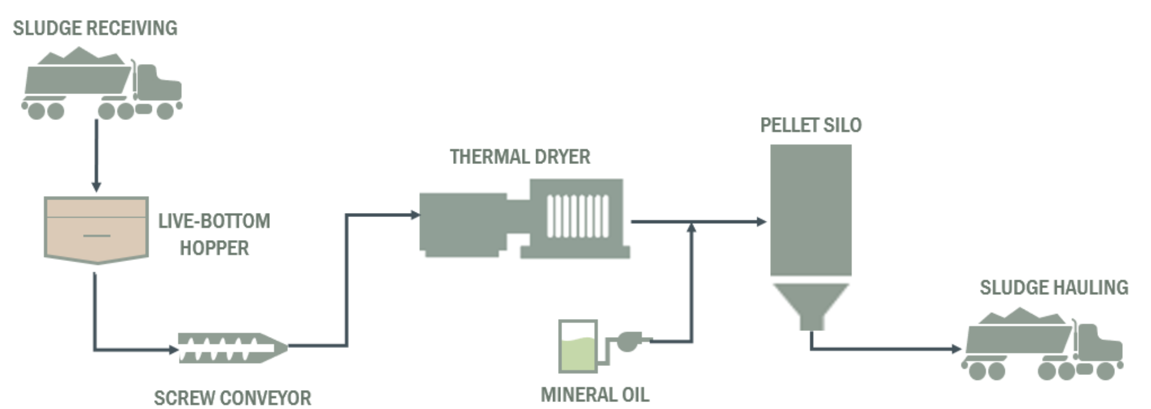


Figure 6-4. Alternative B thermal drying process diagram.

Alternative B Assumptions:

- No major modifications would take place at any RBS Workgroup facilities
- Drum dryer sized based on 13 percent sludge feed concentration for worst case conditions
- Dryer redundancy assumes an n+1 configuration with space for a future dryer installation
- Land is or will be available to construct a regional facility
- Assumed sludge receiving and dewatering would be operated on a daily 8-hour schedule
- A minimum of 2 days of buffer storage would be required for influent sludge

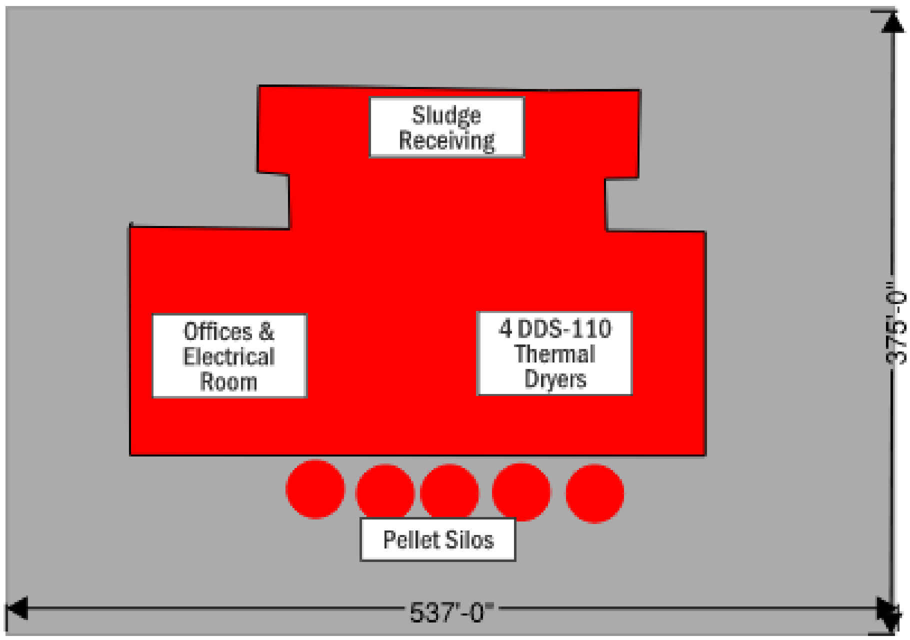


Figure 6-5. Alternative B conceptual layout.

Challenges with this approach:

- Vast range of capital costs for thermal drying equipment and installation
- Low percent TS concentration feeding the dryers results in more and larger units
- Low feed solids results in a high natural gas demand

6.2.2.1 Thermal Drying Site Visit to Palm Beach County

On January 19, 2024, the RBS Workgroup took a tour of the Solid Waste Authority of Palm Beach County's Synagro (formerly NEFCO) biosolids thermal drying facility. The following were general feedback and discussion topics for consideration in proceeding with this type of facility:

- Carefully consider project delivery models, partnerships, and governance. There are several models available that can be implemented depending on needs of the team.
- Site location close to a wastewater treatment plant provides a useful source of reuse water when needed and ease for wastewater disposal.
- Site location close to a landfill can provide needed emergency disposal methods, if possible.

- Considerations are needed for air quality permitting, especially for facilities co-located with other facilities.
- A high level of operator expertise is needed for safe operations.

6.2.3 Alternative C: Composting

Alternative C represents a regional composting facility that would be co-located with a nearby landfill or on a separate parcel or brownfield. Composting is an aerobic process that combines sludge with a bulking material and air to support the degradation of organic materials. The product is then cured and stored for product stabilization. Composting was included as an alternative because it is the least complex process of the alternatives evaluated, has a reasonable time to produce compost (ranges from 45- 60 days), and works well for large volume generators. A conceptual process diagram for Alternative C is shown in Figure 6-6. Significant capital costs associated with this alternative include the following:

- 50-acre compost facility
- Sludge receiving with live bottom hopper and feedstock receiving
- 7.5-acre primary zone
- 8-acre covered secondary zone
- 8-acre covered finished product
- Biofilter system
- Aeration systems

Alternative C provides adequate redundancy and buffer capacity for a regional approach. This approach requires approximately 50 acres of land with space for primary and secondary treatment areas, biofilter, sludge feed, and finished product storage area. Though compost is a simple process, the scale of the 50-acre facility and the staff required to operate it are not insignificant. Additionally, the cost to procure a 50-acre plot elsewhere would be a significant cost to going with this approach. For successful operations, a reliable stream and stockpile of bulking material would be required. The relatively low percent TS for regional biosolids also impacts the efficiency of composting as well and could potentially lead to larger sizing. Due to the scale of the operation, this may pose a challenge. A proposed site layout is shown in Figure 6-7.

Figure 6-6. Alternative C composting process diagram.

Alternative C Assumptions:

- No major modifications would take place at any RBS Workgroup facilities

- An adequate amount of wood chips or other bulking material is readily available
- Land is currently available for this alternative

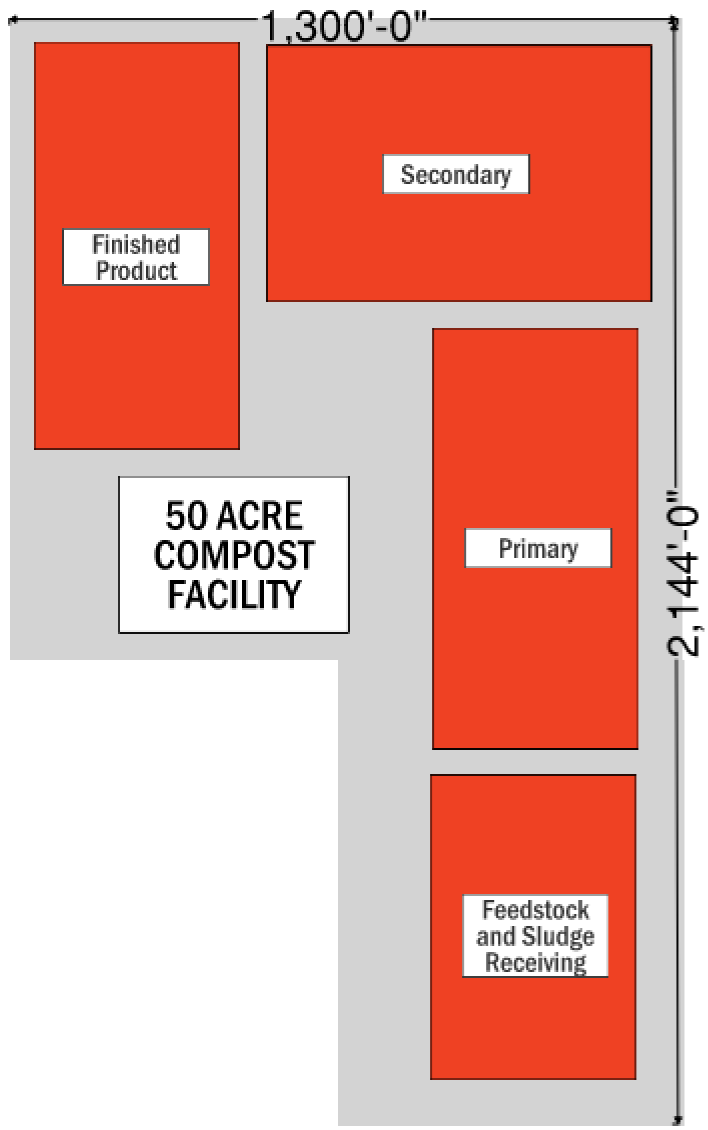


Figure 6-7. Alternative C composting conceptual layout.

Challenges with this approach:

- Composting requires a significant amount of land for the volumes of sludge produced, regionally
- Composting is a relatively simple process but is also labor intensive compared to a few of the other approaches evaluated. Labor demand for composting is the highest of all the alternatives
- Odor control may be an issue depending on where the facility would be located
- Truck traffic for this alternative is significantly higher than the other approaches due to the steady flow of sludge and bulking material required

- Composting generates a marketable product, but it does not decrease overall product volume

6.2.4 Alternative D: Fluidized Bed Incineration

Alternative D represents a regional facility using fluidized bed incineration (FBI). FBI is a technology that uses hot air and a fluidizing medium, like sand, to incinerate sewage sludge. The final product forms an ash, which results in a significant volume reduction of the influent sludge. A conceptual process diagram for Alternative D is shown in Figure 6-8. Significant capital costs associated with this alternative include the following:

- Sludge receiving station with live bottom hoppers
- Sludge conveyance
- Three-100 dtpd FBI units with air pollution controls
- Ash dewatering and loadout
- Air pollution controls

Alternative D provides adequate redundancy and buffer capacity for a regional approach. This approach requires approximately 3-acres of land for a regional incineration facility. This approach requires the smallest footprint and represents the greatest sludge volume reduction compared to the other alternatives. Of all the alternatives, this option is likely to be the most difficult to site and permit due to negative public perception about incineration. Similar to Alternatives A and B, the low solids content in the sludge results in a higher energy demand and increases unit sizes. A proposed site layout is shown in Figure 6-9.

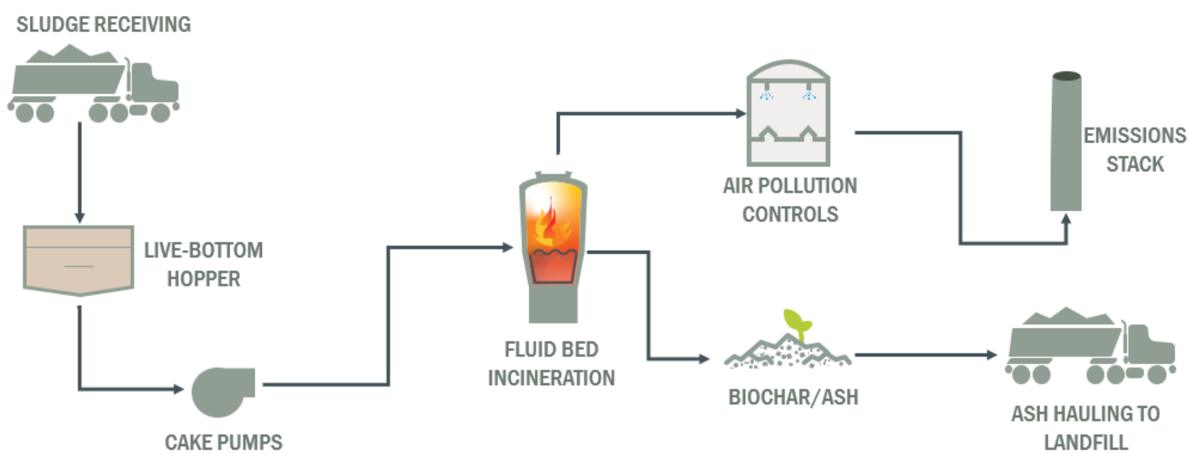


Figure 6-8. Alternative D FBI process diagram.

Alternative D Assumptions:

- No major modifications would take place at any RBS Workgroup facilities
- FBI units sized based on 13 percent sludge feed concentration for worst case conditions
- FBI unit redundancy assumes an n+1 configuration with space for a future installation

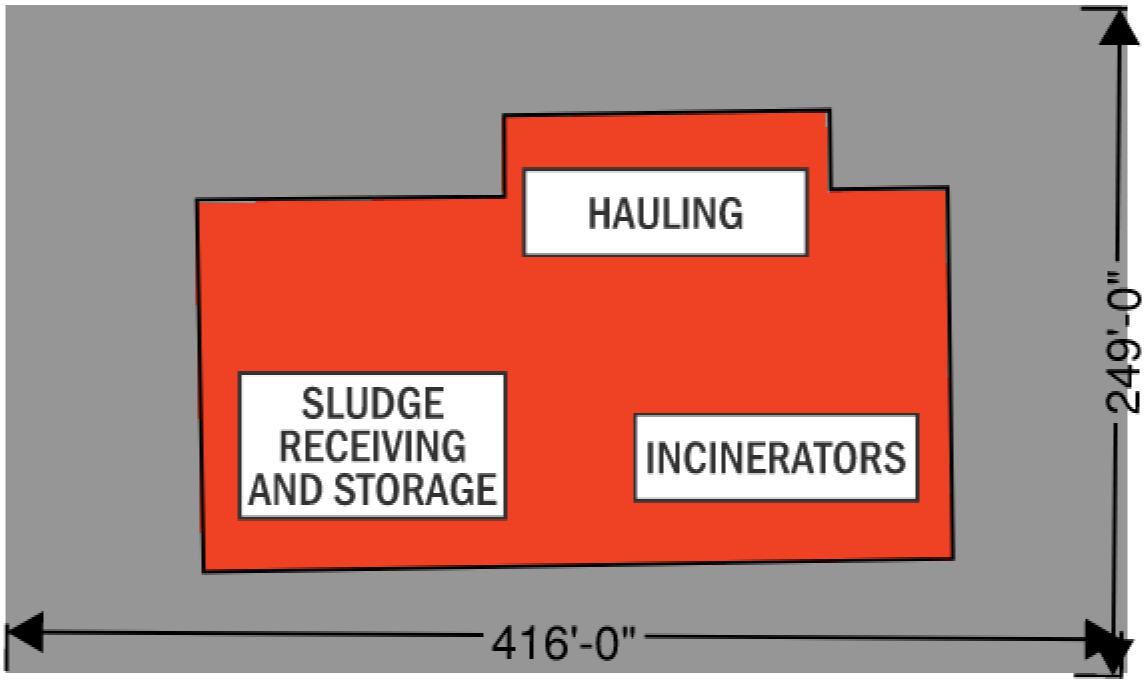


Figure 6-9. Alternative D FBI conceptual layout.

Challenges with this approach:

- Public and political opposition to incineration
- Low percent TS concentration feeding the FBI units results in more and larger units
- Low feed solids results in a high natural gas demand
- Many maintain FBI units with a hot standby and that may not be economical for a regional facility

6.3 NPC – Economic Model

The NPC represents the life-cycle costs of installing and operating a specific capital project over the project lifetime minus the present value of revenue that the project may generate over time. NPC is used in this study to represent the total project cost in present dollars. This analysis is based on average flow and load data with peaking factors applied (Peak day 1.5, Peak Week 1.35, Peak 2-week 1.25, Peak month 1.2). The process analysis begins in 2023 and is projected to 2043 to support a 20-year conceptual study. The following considerations were used to compare alternatives:

- **Operations and Maintenance (O&M) Costs:** The O&M cost inputs in the SWEET model were derived from current operations and loadings and representing an average condition during the 20-year planning period. This includes annual operating costs such as labor, mineral oil, energy, and equipment replacement/repair.
- **New Equipment**: Estimates for new equipment were based on vendor quotes from 2023 or based on previous project experience.
- **Capital Cost Estimates**: Capital cost estimates employ a Class 5 conceptual construction cost estimate, following the standards set by the Association for the Advancement of Cost Engineering International (AACEI). These estimates, subject to a margin of +100/-50 percent, are intended for the purpose of comparing different alternatives. They are not intended for construction cost budgeting purposes. These capital costs are presented to facilitate the evaluation of alternatives and should be thoroughly examined as part of a more detailed cost estimate as the project scope progresses.
- **Utility-Owned Land**: Capital costs assume the availability to use or purchase land in and around Broward County for the construction. Costs related to site cleanup, and permitting fees were not factored into this evaluation.
- **NPC Calculation**: NPC was computed over a 20-year period using a 4.2 percent escalation rate and a 2.2 percent discount rate (Young, 2023) after agreement from the consortium of utilities in Workshop 2. Attachment C contains a summary of the assumptions utilized in the development of the SWEET model.

6.3.1 Operations and Maintenance Costs

Annual O&M unit costs were derived using industry standards, plant-specific data, and insights from experienced utility staff to ensure accurate and practical cost estimation. These costs provide a benchmark for assessing operational efficiency and maintenance demands through the different alternatives. Brown and Caldwell's life-cycle cost assessment considers both operational and capital expenditures. The operational cost projections aim to estimate the operating conditions and unit expenses for a regional facility to achieve this, Brown and Caldwell collaborated with operations personnel to gather actual commodity unit costs and their consumption quantities. Brown and Caldwell then projected future cost estimates by extrapolating from these existing cost parameters. For capital costs, we relied on data from multiple sources to derive our estimates. Table 6-1 in the next section lists several of the key O&M cost assumptions used throughout the SWEET modeling efforts.

6.3.2 SWEET Sensitivity Analysis

Baseline costs for the four remaining alternatives were developed using operations data and costs provided by each utility and presented during Workshop 4. Baseline data allowed Brown and Caldwell to estimate O&M costs. Costs were supplemented with typical industry data and assumptions and utilities were able to provide input ahead of the workshop on any costs they disagreed with. Each participant was provided the following list of parameters to be used in the SWEET Model and were asked if the values seemed accurate and if they wanted the parameter to be considered for sensitivity analysis. The values are presented in Table 6-1.

Table 6-1. Parameters and Assumed Costs Used in SWEET Analysis

Parameter or Cost Element	Units	Assumed Cost
Electricity (blended rate)	$/kilowatt-hour (kWh)	$0.0830
Natural Gas Cost	$/million British thermal units (mmbtu)	$13.00
Value of Biogas	$/mmbtu	$3.00
Diesel Fuel Costs	$/gallon	$3.45
Class B Baseline Hauling and Tip Fee	$/wet ton (wt)	$55
Class AA Cake Land App	$/wt	$30
Class AA Pellet Sale	$/wt	$10
Compost Sale	$/wt	$10
Ash Disposal	$/wt	$40
Bulking Materials Cost	$/wt	$10
Hauling to Regional Facility	$/wt	$10
Average miles to Pellet Sites	mile	30
Average miles to Compost Sites	mile	100
Average miles to Class AA Site	mile	120
THP Dewatered Hauled Cake	%TS	24%
Total Solids of Anaerobic Digested Solids Feed	%TS	15.0%
Total Solids of Aerobic Digested Solids Feed	%TS	13.5%
THP liquid waste stream treatment	$/year	$60,000
Other alternatives liquid waste stream treatment	$/year	$6,000
Florida Grant for Capital Cost	$	$0
Life Cycle	Years	30
Escalation rate	Annual Percentage Rate (%APR)	4.2%
Discount rate	%APR	2.2%
Land Costs per Acre	$M/Acre	$2.5 M

It should be noted that the values in Table 6-1 for hauling and tip fee is the weighted average rate that the municipalities currently see, but that this value is not stable. Communities are experiencing increased biosolids hauling and tip fees even over the course of this conceptual study. Class B end use outlets are decreasing, as noted above, which could cause an increase in costs as utilities will have fewer outlets. Depending on the ability of locations to accept biosolids due to increased legislative pressures, and the availability of landfill space, it would be reasonable to assume this number could double or triple between the time of this study and the construction of a regional solution. An estimated value based on current information had to be used for the cost analysis, but the likely future cost is much higher.

6.4 SWEET Analysis Results – Initial Four Alternatives (Workshop 4)

Following the sensitivity analysis discussion, two graphs showing the results of the economic comparison from the SWEET models were presented. Figure 6-10 represents the Net Present Worth Comparison of each alternative which includes capital costs, O&M costs, labor, energy use, hauling, and other key parameters. Figure 6-11 represents an Annual Cost Comparison for operating and maintaining the facilities for each alternative. Note that these are conceptual estimates based on experience and best available information. Ultimate values may vary depending on owner preferences, market and/or regulatory impacts, inflation, or other local impacts. Thermal dryers can have a vast range of capital costs ($200M to $560M) as it depends on the type, size and number of thermal dryers assumed in the design. This project assumed drum dryers, which tends to be one of the most expensive in the industry, but they produce a desirable and sellable product. This chart displays the most expensive option with thermal dryer redundancy. This chart displays the most conservative option.

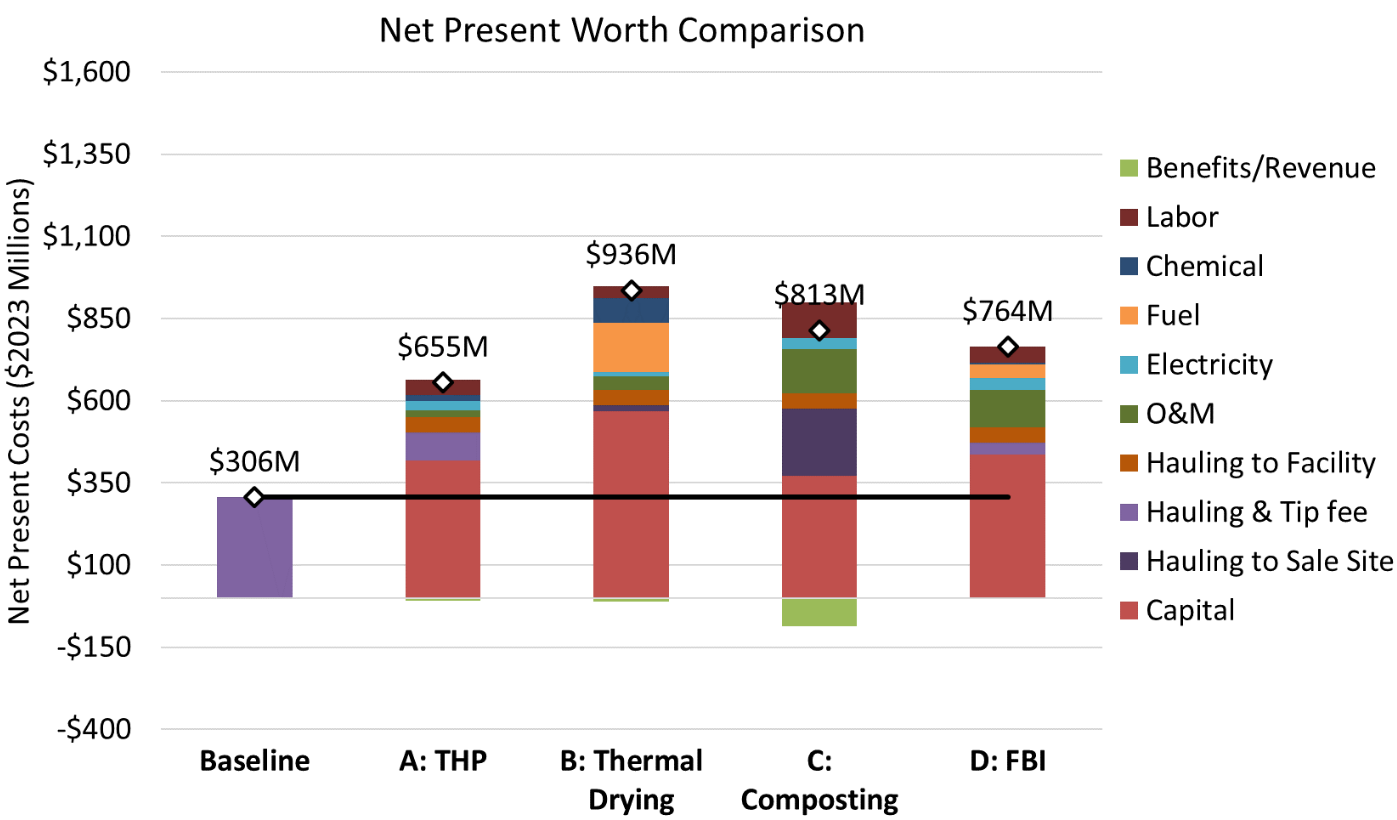


Figure 6-10. Net present worth comparison.

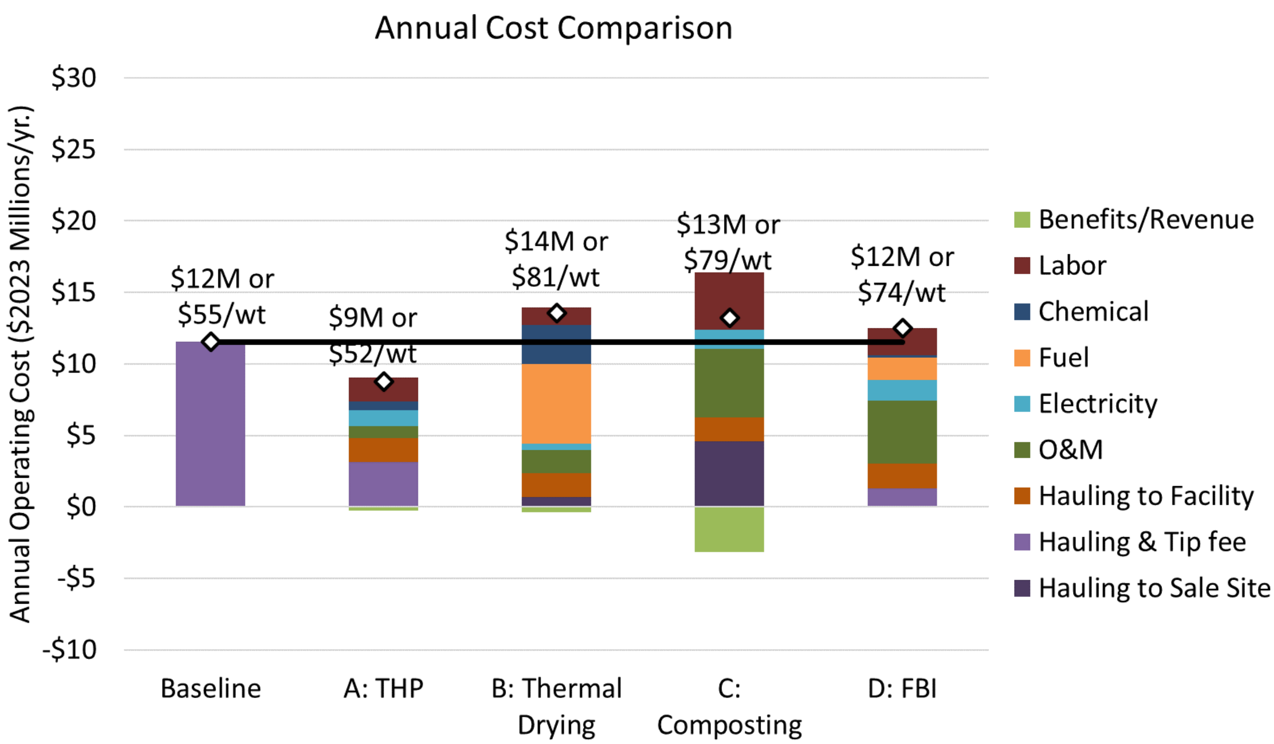


Figure 6-11. Annual cost comparison.

6.4.1 Ranking and Hybrid Options

The workshop attendees were then tasked, using the information above and discussions held in Workshop 4, with narrowing down the four alternatives to two final options and determining if there is a hybrid option that could be worth exploring. Each utility completed a ranking sheet (1 for the technology they were most interested in and 4 for the lowest preference technology) and were asked for reasons for their technology rankings. A summary of this outcome is in Table 6-2 below.

Table 6-2. Technology Ranking During Workshop 4

Technology	Number of 1st place rankings	Number of 2nd place rankings	Number of 3rd place rankings	Number of 4th place rankings	Reasons for top ranking
THP	9	1	-	-	Overall cost, land requirement, chemical cost, maintenance cost, efficiency, volume reduction
Composting	-	-	3	7	-
Thermal Drying	1	3	5	1	Overall cost, Proven technology, most established installations, reliability
Fluidized Bed Incineration	-	6	2	2	-

This analysis and subsequent discussion ultimately eliminated Composting and Fluidized Bed Incineration, moved THP and Thermal Drying forward, and prompted an additional evaluation into a hybrid/sub alternatives of THP with renewable natural gas (RNG) and renewable identification number (RINs) sale, and Thermal Drying with Solar Drying pretreatment to reduce the natural gas use. This was explored further during Workshop 5.

6.5 Refining the SWEET Analysis – Final Alternatives (Workshop 5)

The goal of Workshop 5 was to review the remaining alternatives and narrow them down to one option that would move on to the site assessment analysis, delivery model alternatives analysis, and final recommendation. The remaining technologies and hybrid options were again presented to the group for discussion including existing installation examples. The options are shown in Figure 6-12.

Alt A1	Thermal Hydrolysis
Alt A2	Thermal Hydrolysis with RINs
Alt B1	Thermal Drying
Alt B2	Thermal Drying with Solar

Figure 6-12. List of final alternatives modeled in SWEET.

6.5.1 Alternative A1: Thermal Hydrolysis

Alternative A1 is identical to the approach laid out in Section 6.2.1. This section is presented here to show each approach discussed in Workshop 5 along with installation and previous experiences.

Capital Elements: Sludge receiving station with live bottom hoppers, sludge storage tanks (2-day storage), Four THP B6.4 units (CAMBI), two - 3 MG mesophilic digesters, digested sludge storage tank, belt filter press dewatering units, filtrate sump pumps, and steam boiler. A conceptual process diagram is shown in Figure 6-13.

Installations and Experiences: The team is aware of about 7 installations of THP (Cambi) in operation and an additional 6 under construction. Two major examples are located at DC Water (Washington DC) and Trinity River Authority (Dallas, TX). These installations process 1200 and 120 dry tons of biosolids per day respectively. DC Water's Cambi system came online in 2014 and Trinity River Authority's system in 2023.

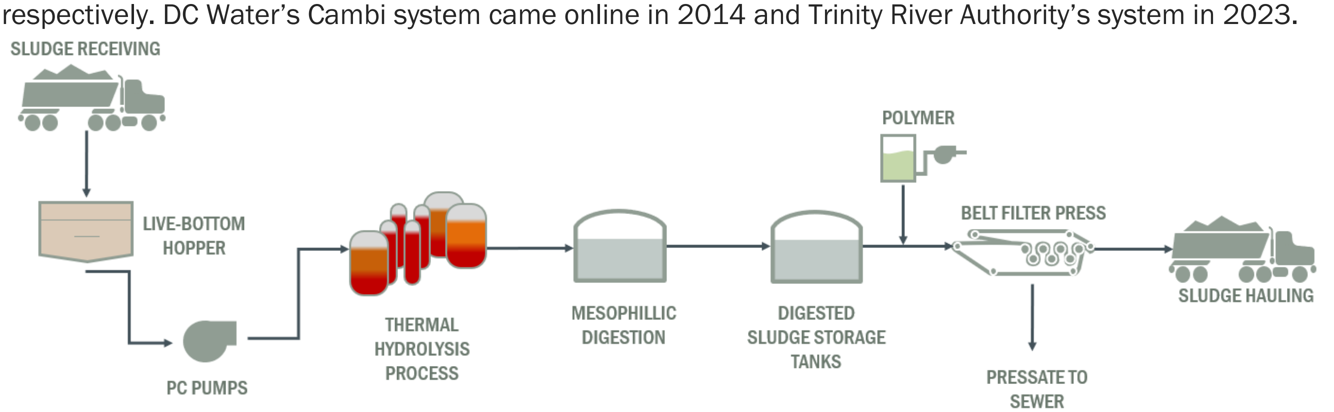


Figure 6-13. Alternative A1 thermal hydrolysis process flow schematic.

6.5.2 Alternative A2: Thermal Hydrolysis + RINs

Alternative A2 includes the same capital elements as Alternative A1, but it would also upgrade the excess biogas, as in more than what is needed to fuel the boilers, to RNG quality. The intention would be to sell this RNG to a large-volume natural-gas-for-transportation user (like a local bus fleet) and then sell the RINs (which are like renewable energy credits or "RECs", but for vehicle fuel) to Renewable Fuel Standard "obligated party" (typically a petroleum refiner). A conceptual process diagram is shown in Figure 6-14.

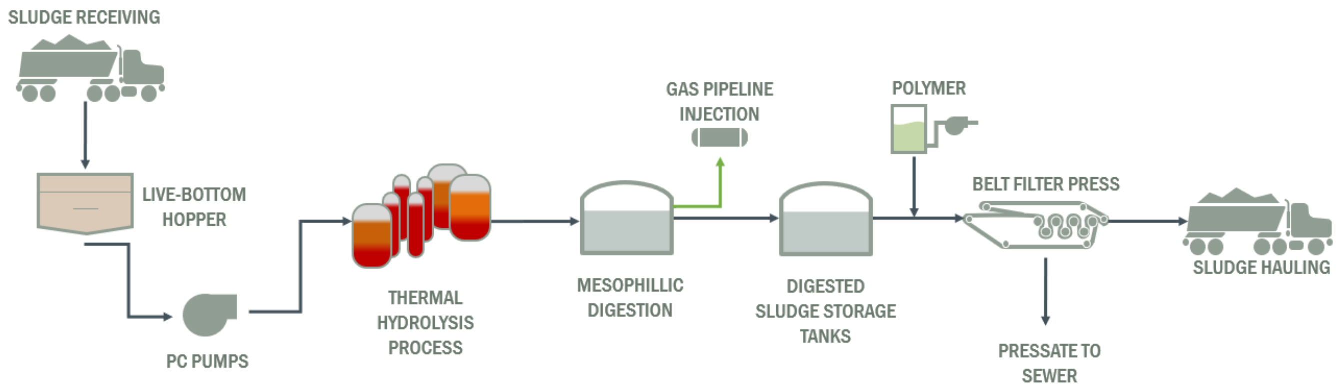


Figure 6-14. Alternative A2 thermal hydrolysis process with RINs process flow schematic.

6.5.3 Alternative B1: Thermal Drying

Capital Elements: Sludge receiving station with live bottom hoppers, sludge conveyance, four – DDS110 Thermal Dryers, four RTOs for odor control, and five pellet silos. A conceptual process diagram is shown in Figure 6-15.

Installations and Experiences: The team is aware of hundreds of installations, and in operation, since at least the 1950s. The nearest example of a thermal dryer is located at the Palm Beach County Solid Waste Authority (West Palm Beach, FL). This facility, as is mentioned in Section 4.1 of this report, accepts a maximum of about 600 wet tons of biosolids per day and has been online since 2009.

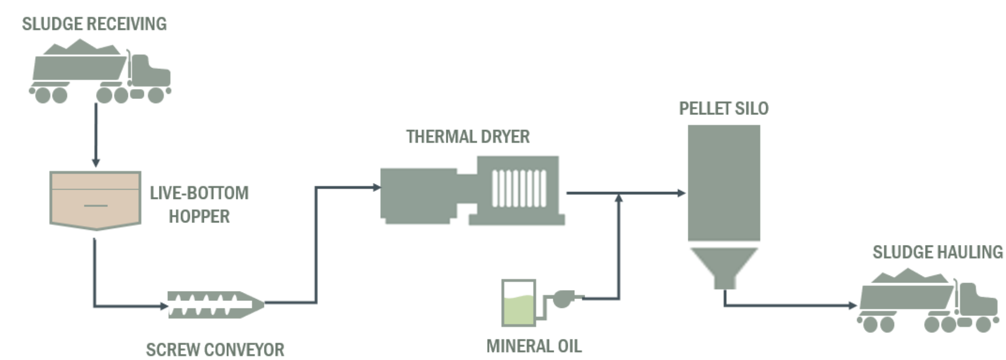


Figure 6-15. Alternative B1 thermal drying process flow schematic.

6.5.4 Alternative B2: Thermal Drying with Solar Drying (Hybrid Approach)

Capital Elements: Ten solar green houses on five additional acres, three DDS 110 Thermal Dryers and recovered exhaust heat from the dryers used to heat the floors of the solar dryers. The goal is to increase the solids content to the thermal dryers to a more-typical 20-26 percent solids, thereby requiring one fewer duty (and total) dryers. The use of the solar dryer and exhaust heat recovery would offset the natural gas use/costs by 54%. A conceptual process diagram is shown in Figure 6-16.

Installations and Experiences: Merrell Bros, Inc. has constructed their FloridaGreen solar drying facility in Pasco County, FL that processes about 137 wet tons of biosolids per day. This facility uses solar drying and belt drying polishing step, which they call an oven pasteurization step, to produce a Class A product. In another location, solar dryer greenhouse with heated flooring, similar to that envisioned here, was installed in Surprise, Arizona; and is currently undergoing commissioning and performance testing to prove Class A compliance.

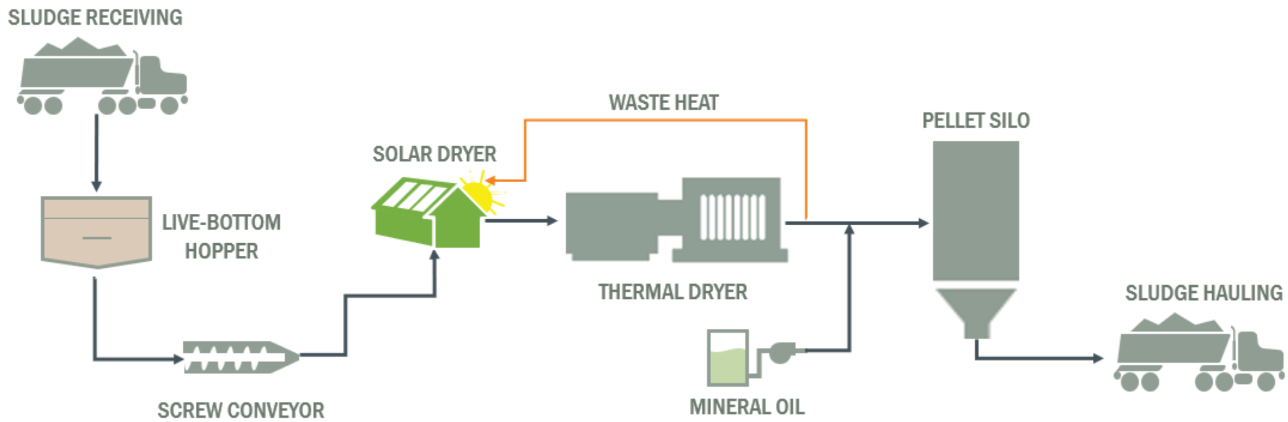


Figure 6-16. Alternative B2 hybrid flow schematic.

6.6 SWEET Analysis Results – Final Alternatives (Workshop 5)

Following the sensitivity analysis discussion, two graphs showing the results of the economic comparison from the SWEET models were presented. Figure 6-17 represents the Net Present Worth Comparison of each alternative which includes capital costs, O&M costs, labor, energy use, hauling, and other key parameters. Figure 6-18 represents an Annual Cost Comparison for operating and maintaining the facilities for each alternative. Note that these are conceptual estimates based on experience and best available information. Ultimate values may vary depending on owner preferences, market and/or regulatory impacts, inflation, or other local impacts.

Of note in this Section 6.6's economic figures, the depiction of a continued cost for Class B biosolids of $55/wt (used in Table 6-1 and Figures 6-17 and 6-18) is considered unsustainable over the next 5 years, let alone for the 20-year life cycle represented in the figures. As such, two new thresholds have been depicted for the Baseline in the Figures 6-17 and -18. The darkest purple bar shows costs at today's $55/wt; whereas the medium-purple bar increases the assumed cost to $120/wt and the lightest-purple bar is shown for $150/wt cost. Brown and Caldwell expects the average hauling and land application cost for Class B biosolids over the 20-year life cycle to be between $120/wt and $150/wt; and would suggest that maintenance of the status quo for most utilities be assessed against those considerably-higher-than-current unit costs.

During Workshop 5, there were discussions among the participants that further narrowed the technologies selection to thermal drying. While on a cost basis, the THP alternative costs less than thermal drying, thermal drying reduces the volume of solids significantly more than THP does as thermal drying removes approximately 90 to 95 percent of the water from sludge, which also significantly reduces the number the trucks that would need to leave the facility. In 2043, it is estimated that 91 and 42 trucks per year (at 20 tons per truck) would leave the facility for THP and thermal drying, respectively. The thermal dryers modeled for this study were drum dryers, which produce a sellable pellet. Additionally, if a sellable product was not a goal, a different dryer type could be used, which would have a lower capital cost. Moreover, as mentioned previously, solar drying was evaluated to increase the initial solids content to reduce the number of dryers needed as well as natural gas consumption, during conceptual design alternatives can be evaluated to achieve these same results at a lower capital costs. These could include such things as utilizing waste heat from the dryers or trying a new technology such as Elode.

In addition, during the workshop, we discussed that thermal dryers do have third party vendors like Stircor that provide mobile dewatering units, which THP does not. In these types of step-ups, the vendor has a contract on cost per wet ton basis. This cost typically covers the costs associated with labor, natural gas, electricity, and solids disposition. Finally, if the County had to pivot to address PFAS mitigation in sludge, the two most promising and commercially advanced technologies currently on the market, pyrolysis and gasification, require sludge drying as the initial step.

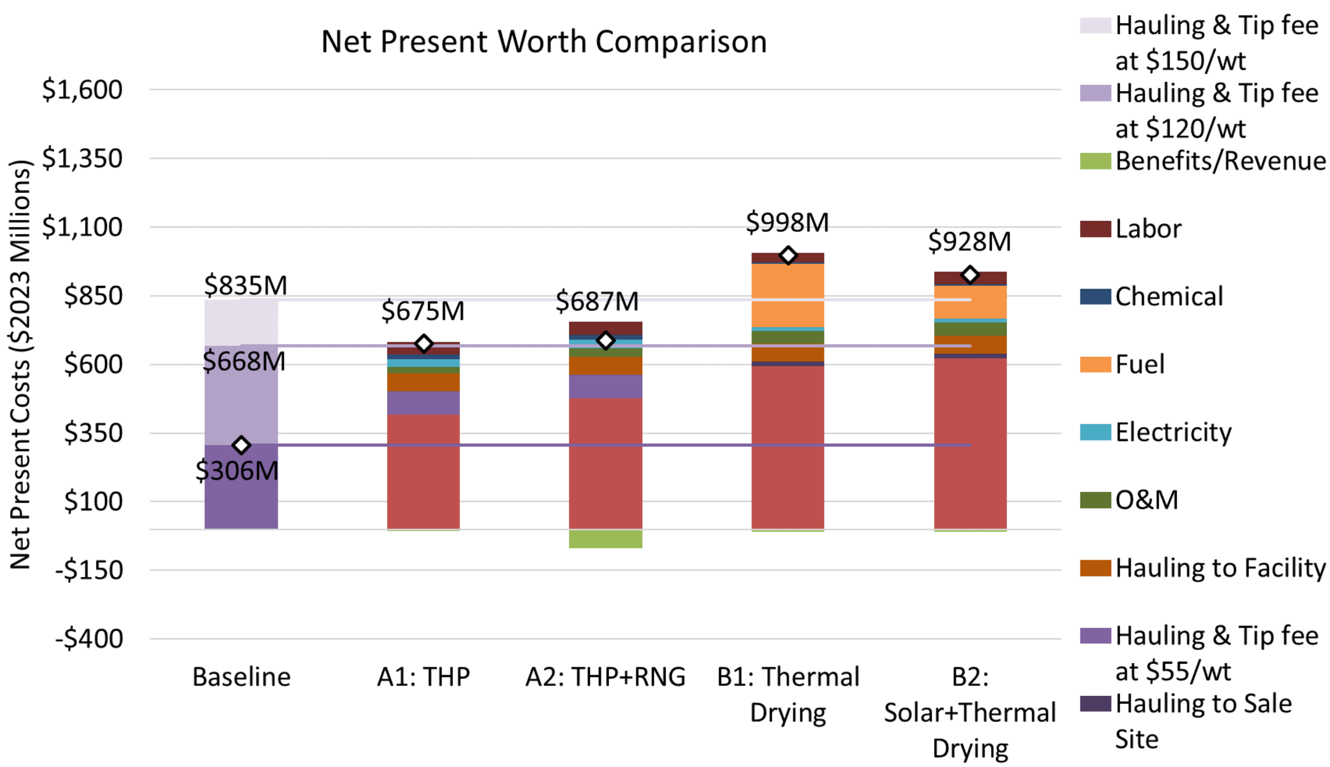


Figure 6-17. Net present worth comparison.

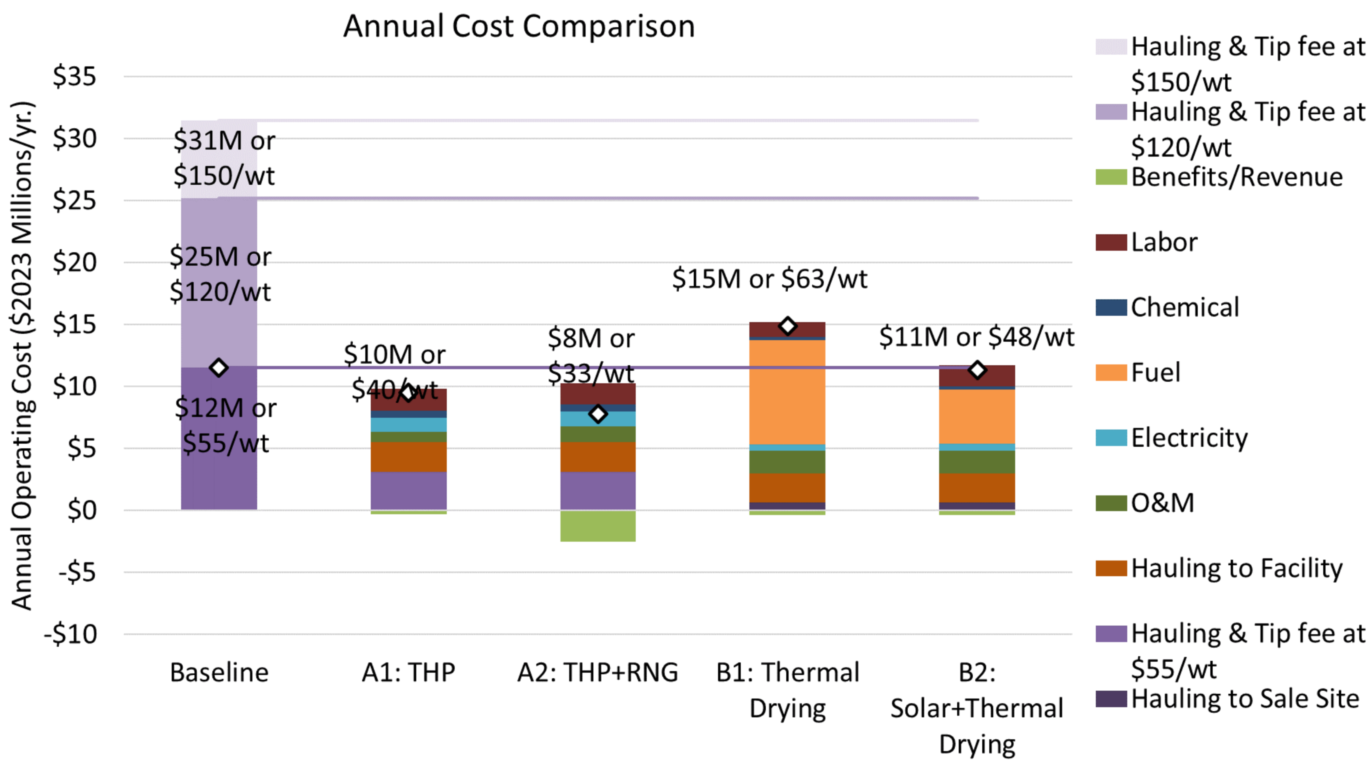


Figure 6-18. Annual cost comparison.

Section 7: Site Assessment Alternatives Analysis

7.1 Site Requirements

The evaluation of available sites started during the assessment of representative technologies to determine whether the availability of a site may be a limiting criterion of concern for certain technologies. The base criteria for the selection of a potential biosolids stabilization facility site included the following criteria:

- Available Size
- Accessibility to Reclaimed Water
- Accessibility to Natural Gas
- Accessibility to Water
- Accessibility to Wastewater Collection Systems
- Accessibility to power
- Proximity to WWTP
- Proximity to Landfills
- Ownership preference:
  1. Government Owned
  2. Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals
  3. Privately Owned (all others)

Of these factors the site's available size was the primary concern in selecting feasible sites for final evaluation. Different technological alternatives required varying available space to accommodate the biosolids stabilization facility. From the highest ranked three representative technologies under consideration, the relative required minimum available vacant space within a site varied as follows:

- THP [≥ 4 acres]
- Thermal Dryers [≥ 5 acres]
- Thermal Dryers with Solar hybrid alternative [≥ 10 acres]

Initial site evaluations focused on the required minimum size of potentially available vacant parcels within Broward County that were further segregated by parcel use code ownership as follows:

- Vacant Residential
- Vacant Commercial
- Vacant Industrial
- Vacant Institutional
- Vacant Government
- Municipal Other than Parks, Recreational Areas, Colleges, and Hospitals

Investigations found the following potential available parcels for each of the three representative technologies as summarized in Tables 7-1, 7-2 and 7-3.

Table 7-1. Available Vacant Sites [≥ 4 acres]	
Vacant Residential	393
Vacant Commercial	89
Vacant Industrial	52
Vacant Institutional	13
Vacant Government	119
Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals	128
TOTAL	**794**

Table 7-2. Available Vacant Sites [≥ 5 acres]	
Vacant Residential	283
Vacant Commercial	63
Vacant Industrial	40
Vacant Institutional	10
Vacant Government	107
Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals	114
TOTAL	**617**

Table 7-3. Available Vacant Sites [≥ 10 acres]	
Vacant Residential	212
Vacant Commercial	24
Vacant Industrial	15
Vacant Institutional	1
Vacant Government	63
Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals	61
TOTAL	**376**

The assessment and ranking of representative technologies were finalized and Thermal Dryers were selected as the desired alternative. This set the minimum required available vacant space on a potential site to five (5) acres or greater, leaving 617 sites as potential alternatives for evaluation.

Following the initial site evaluations, the RBS Workgroup made the decision to focus on vacant government owned sites to eliminate potential additional complexities and reduce costs associated with site procurement. This narrowed the potential sites to 107 for consideration.

Following Workshop 5, spreadsheets were distributed to each of the participating municipal utilities with the potential vacant government owned sites within each utility's service area to help eliminate any sites that may be considered vacant but were not actually available (e.g. already designated for an alternative use). From this exercise, and the feedback received from utilities, an additional 35 sites were eliminated. This brought the number of potential sites for consideration down to 72. Additionally, six sites were added by participants while reviewing the spreadsheet, bringing the total number of potential sites to 78. Given the quantity of potential sites remaining for evaluation, additional site criteria were required.

As mentioned in Section 6.2.2.1, a site visit was made to the biosolids treatment facility in Palm Beach County. During this trip, the staff emphasized the importance of two key considerations in siting such a facility: proximity to wastewater treatment facilities and proximity to landfills. With this feedback, the remaining potential vacant sites were further evaluated to focus on the potentially available site's distance to a wastewater treatment plant and landfill. Twelve (12) wastewater treatment facilities (only including municipalities within this working group) and three (3) active landfills are contained with Broward County. The refined site selection criteria utilized was as follows:

- Proximity to WWTP (within 1 mile)
- Proximity to Landfills
- Vacant Government Owned Properties (≥ 5 acres of available space)
- Access to Reclaimed Water
- Access to Natural Gas
- Access to Potable Water
- Access to Sanitary Sewer
- Access to Power

Figure 7-1 below represents the locations of the landfills (orange polygons) and WWTPs (green dots) with a one-mile radius depicted around the WWTP sites (blue circles).

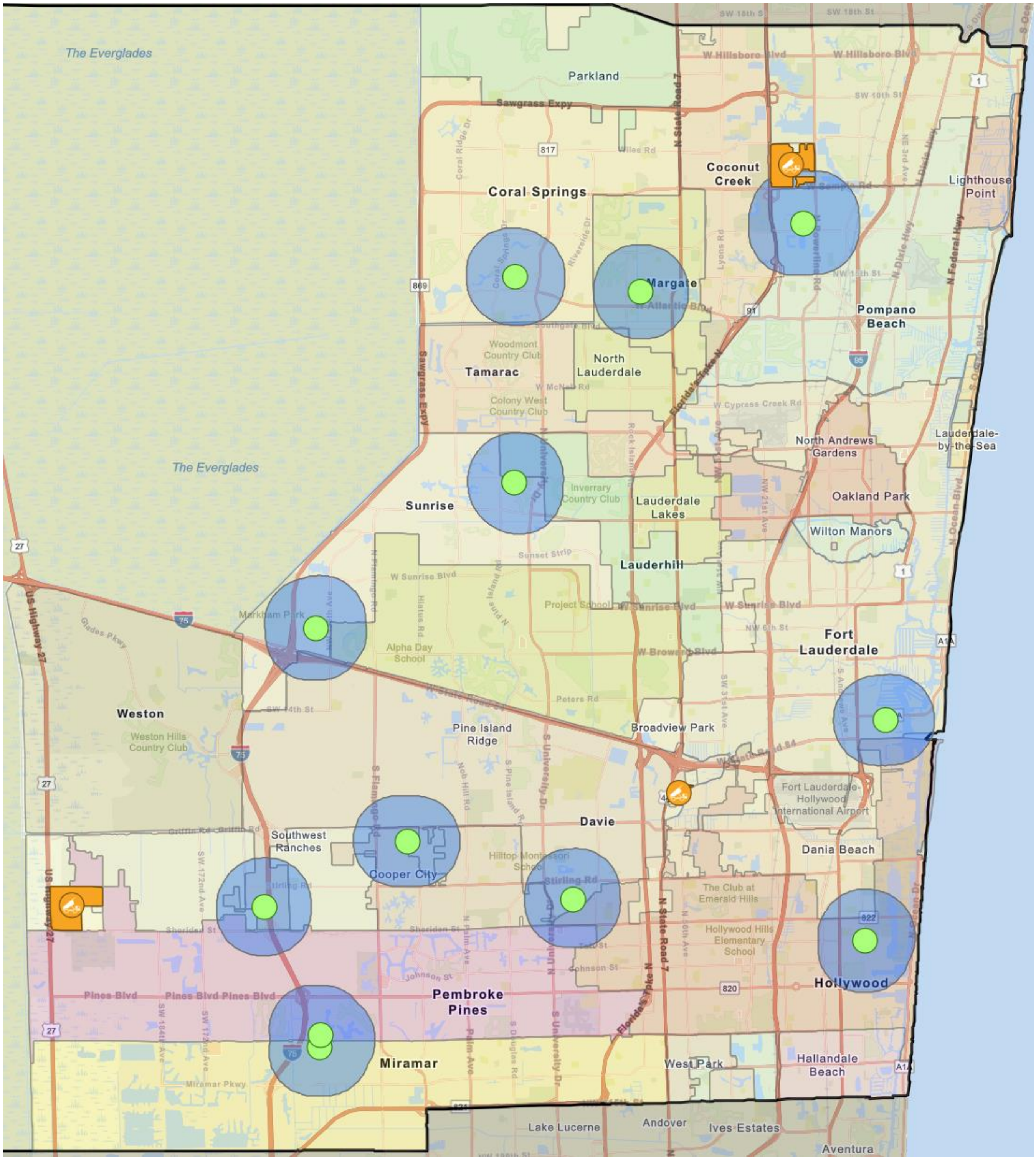


Figure 7-1. Landfills and WWTPs with 1-mile radii.

7.2 Local Sites

With the updated criteria, sixty-one (61) vacant sites were found to be within one mile of an existing wastewater treatment facility and sixteen (16) of those were government owned as summarized in Table 7-4.

Table 7-4. Available Government Owned Vacant Sites [≥ 5 acres]		
Potential Vacant Site No.	WWTP Utility Service Area	Site Folio Number
1	City of Margate WWTP	484125030010
2	City of Hollywood WWTP	514203690020
3	City of Margate WWTP	484135012670
4	City of Fort Lauderdale WWTP	504223000420
5	Broward County WWTP	484221120050
6 - 16	City of Sunrise (Springtree WWTP)	494120AB0010
		494120AB0020
		494120AB0030
		494120AB0040
		494120AB0050
		494120AB0080
		494120AB0090
		494120AB0150
		494120AB0160
		494120AB0190
		494120AB0200

These sites were then more closely evaluated to assess their potential use. The 11 folio numbers listed in the City of Sunrise's Springtree's WWTP area, Vacant Sites Numbered 6 – 16, were found to all be located on a single 11-acre parcel, which happened not to be vacant and appears to have government housing. Therefore, these sites were eliminated from further consideration.

Vacant Site No. 2, located north of Hollywood's WWTP area and adjacent to Olsen Junior High School, is owned by the school board and was found not to be vacant. Therefore, this site was eliminated from further consideration.

Vacant Site No. 3, located in Margate's WWTP area, was found to contain high voltage lines running through its middle and therefore eliminated from further investigation.

Vacant Site No. 4, located within the City of Fort Lauderdale's WWTP area and adjacent to the port facilities, is owned by Broward County and was reported by the County not to be available for use. Therefore, this site was eliminated from further investigation.

Finally, a follow up email to the City of Margate found that Vacant Site No. 1, located in Margate's WWTP area, was already designated for a future specific use and was not available for consideration; thus, this site was also eliminated from further consideration.

Thus, only one (1) of the original 16 vacant government owned sites was available for final consideration (Site No. 5). From the feedback we received from the distribution of spreadsheets following Workshop 5, a potential five (5) additional sites were also recommended for consideration. These happened to be parcels that were partially utilized or didn't meet the 5-acre criteria but were adjacent to other Broward County owned parcels that corrected that deficiency. All these sites also happened to be within a mile from the WWTP and met updated site criteria. Thus, a total of six sites remained for final evaluation as summarized in Table 7-5.

Table 7-5. Final Sites for Evaluation

Final Selected Site No.	WWTP Service Area	Total Area (Acres)	Site Availability (Vacant / Partially Utilized)	Distance (miles) to: WWTP	Distance (miles) to: Landfill
1	Broward County WWTP	11.39	Partially Utilized	0.15	0.55
2	Broward County WWTP	36.58	Partially Utilized	0.03	0.69
3	Broward County WWTP	3.21	Partially Utilized	0	0.57
4	Broward County WWTP Site	77.09	Partially Utilized	WWTP	0.72
5	Broward County WWTP	22.06	Vacant	0.13	0.57
6	Broward County WWTP	30.99	Partially Utilized	0	0.71

Figure 7-2 summarizes the six sites within the Broward County WWTP Service Area inclusive of the actual WWTP site (Final Selected Site No. 4). All these sites are within 0.72 miles from the nearest landfill as shown in Table 7-5 and at or adjacent to the existing WWTP. All these sites have easy access to utilities including reclaimed water. The exact location of the nearest natural gas line is unknown but is presumed to have a major arterial pipeline that runs adjacent to the Turnpike which is near to all the sites. Additionally, the extreme proximity to the landfill avails options for the provision of alternative gas supplies (i.e. using methane from the landfill).

The study also identified a few properties adjacent to or in proximity of the North Regional WWTP that, while they have been eliminated from consideration at this time, may be looked at again when the site selection is made. During the design phase, all properties adjacent to or in proximity of the North Regional WWTP should be considered for construction, ingress, and egress purposes.

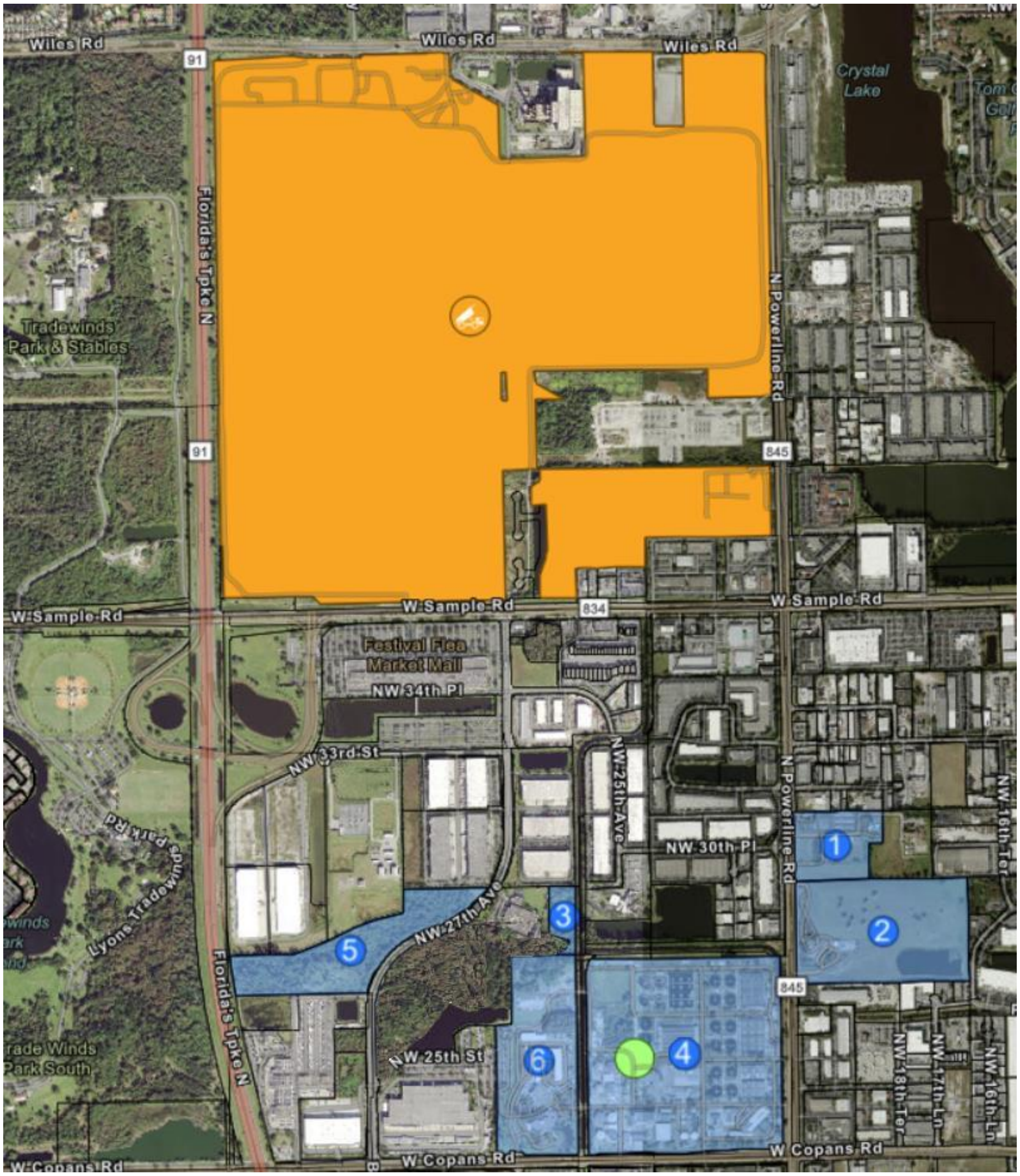


Figure 7-2. Selected Sites 1 – 6 for Evaluation (Broward County WWTP Service Area).

Given the remaining six sites' proximity to one another and their ability to be utilized in conjunction with one another, the final site selection is inclusive of all six sites shown (Final Selected Sites No. 1–6). The final layout and identification of the exact location within these given six sites for the biosolids stabilization facility will be determined in the next phase of evaluation in close conjunction with WWS. It should be noted that if these sites (and any others that become available after this project phase) are up for prime consideration, then additional collaboration with the County and other appropriate parties is necessary.

Section 8: Delivery and Governance Model Alternatives Analysis

In addition to planning level costs and site assessment, the RBS Workgroup needs to assess the governance model and delivery method. In this section discussion will be around the organizational structure of the project, Governance, and potential delivery methodology. For governance it is important to understand who will participate and who the actual owner of the facility will be. This will impact funding options, level of service and allowable procurement methods as well as how each member will be associated with the project and to what level of decision authority they will have. Development of the Governance and guidelines of engagement will then assist in determining the risk structure and methodology to design and construct the project.

8.1 Governance Tracks

This section outlines three distinct tracks for implementation of a regional biosolids management approach: Single Utility Ownership, Participation in Existing or development of a Regional Organization, and Public/Private Partnership (PPP). The privatization track was not looked at as an option; however, it is not anticipated as feasible means to implement a regional system. Each model offers unique advantages and considerations. The decision on which model to adopt should align with project goals, risk tolerance, and stakeholder engagement, and will be discussed in further detail during a future phase of work. The sections below present a high-level overview of these three potential models.

8.1.1 Track 1 – Utility Control

Track 1 is a Single Utility Ownership model in which a single utility entity owns and operates the waste management facility. The utility would enter into contracts with individual facilities to handle their waste. This single utility would have sole responsibility for waste disposal. The benefit of this approach is that collaborative agreements allow a distribution of risk among stakeholders. The Single Utility Ownership model also qualifies for Water Infrastructure Finance and Innovation Act (WIFIA) funding, which is designed to accelerate investment in water infrastructure projects.

8.1.2 Track 2 – Participation in an Existing Regional System

Track 2 is the Integration with Regional System model, which involves participation in an existing regional system. Integration with an existing regional system facilitates participation in an established regional waste management system that allocates risk across participating entities. Although a current regional organization is not in place, the interested Broward Utilities could create one for this project. This model also qualifies for WIFIA funding but may introduce scheduling and coordination complexities within a larger system. Sharing the responsibilities does reduce individual facility risk and fosters efficiency.

8.1.3 Track 3 – Public / Private Partnership

Track 3 is the PPP and allows partnerships between public and private entities. The private financing allows higher costs to be offset by performance certainty, efficiency gains, and innovation. This in turn creates a robust financial mechanism that defines clear roles for project company, equity, and debt. Creating a strategic partner engagement depends heavily on early and ongoing collaboration with partners.

8.2 Project Delivery Approaches

Various project delivery methods were analyzed at a high level to assist the Participating Utilities in selecting the most suitable approach for this specific project. Table 8-1, Table 8-2, and Table 8-3, shown on the following page, summarize the advantages and disadvantages of three prominent project delivery methods:

Traditional Design-Bid-Build (DBB), Construction Manager at Risk (CMAR), and Progressive Design-Build (PDB). Delivery method, like governance model, will be discussed in greater detail in a future phase of work.

Table 8-1. Traditional Design-Bid-Build Advantages and Disadvantages

Traditional Design-Bid-Build (DBB)	
Advantages	**Disadvantages**
Familiar delivery method.	Linear and sequential process
Owner controls design.	Costs are uncertain until bids are received.
No legal barriers.	Selection based on low bid.
Permitting agencies familiar with the process.	Owner warrants design.
The owner gets the low competitive price for the project that is bid on.	No contractor input into the design.
	Difficult to make contractor qualifications part of the bid.

Table 8-2. Construction Manager at Risk Advantages and Disadvantages

Construction Manager at Risk (CMAR)	
Advantages	**Disadvantages**
Focus on constructability efficiency.	Multiple entities and contracts.
Straight forward contract	Multiple points of responsibility.
Preserves owner control throughout the design.	Construction cost unknown at initial contract signing.
100% of the equipment and subcontracts are competitively bid.	May need a public education campaign.
Involvement of construction professionals throughout design.	Performance Risk remains with the Owner.
Owner has off-ramp prior to GMP approvals.	

Table 8-3. Progressive Design-Build Advantages and Disadvantages

Progressive Design-Build (PDB)	
Advantages	**Disadvantages**
Single point of responsibility.	Construction cost unknown at initial contract signing.
Preserves owner control throughout the design.	May need a public education campaign.
100% of the equipment and subcontracts are competitively bid.	
Shortest schedule for procurement and construction.	
Owner has off-ramp prior to GMP approval.	

8.3 Funding Opportunities

As mentioned previously the governance and delivery model chosen will have an impact on the availability and type of funding for this project. The following funding sources are some, but not all, of the available funding opportunities that the RBS Workgroup should explore moving forward and it is entirely likely that a combination of sources will be required for a project of this scale.

Biosolids Grant Program (Florida Statute 403.0674): Starting July 1, 2023, Florida Statute 403.0674 was created to establish a biosolids grant program within the FDEP, which authorizes the Department to provide grants to counties and municipalities that are working on projects that implement innovative technologies for biosolids disposal and/or convert wastewater residuals to Class AA biosolids. Applications are encouraged to form public-private partnerships. For a project to be eligible for funding, they must either reduce the amount of nutrients in biosolids, reduce the amount of emerging contaminants in biosolids, and/or provide alternatives to land application or landfilling as primary biosolids disposal methods. The Department will review to confirm that the project minimizes the migration of nutrients and other pollutants that degrade water quality. While this statute is subjected to funding appropriated by the legislature, the Department is expected to provide up to 50 percent funding and require a funding match.

Water Infrastructure Finance and Innovation Act (WIFIA): As mentioned previously, WIFIA established in 2014, is a federal loan program administered by the EPA. Its primary goal is to accelerate investment in the nation's water infrastructure. WIFIA provides long-term, low-cost supplemental financing for water and wastewater infrastructure projects of national or regional significance. WIFIA offers subsidized loans to eligible entities, including state and local governments, tribes, corporations, and partnerships, that can be used for a wide range of water-related projects, such as drinking water treatment systems, wastewater treatment facilities, and biosolids management. Entities seeking WIFIA financing for biosolids projects should demonstrate their project's regional or national significance and its potential environmental benefits.

State Revolving Funds (SRFs): The State Revolving Funds (SRFs) are essential financial programs that provide subsidized loans and other assistance to support water infrastructure projects. These funds operate as revolving loan pools. Capitalization from the federal government allows states to issue loans, receive repayments, and use the repaid capital to fund new projects perpetually.

One key component of the SRFs is the Clean Water State Revolving Fund (CWSRF). Administered by the EPA, the CWSRF offers low-cost financing to communities for various water quality infrastructure projects. These projects include upgrading or constructing municipal wastewater treatment plants, addressing nonpoint source pollution (e.g., runoff from urban areas and agriculture), supporting decentralized wastewater treatment systems, managing stormwater runoff, implementing green infrastructure practices, preserving estuaries, and promoting water reuse. Biosolids projects in particular can be funded by SRFs when used for the upgrade, repair, replacement or installation of new biosolids dewatering and residuals handling equipment as well as when the project relates to drying, dewatering, and energy conversion equipment.

Section 9: Summary of Recommendations

9.1 Technology Evaluation Summary

This project is a conceptual study of a regional biosolids solution(s) for the RBS Workgroup, in response to the challenges and uncertainties of biosolids management in South Florida. This project has completed the first two phases as detailed above: data development and alternatives analysis. This section will summarize key findings from these phases. During early research, it was reported that the recent changes in Florida rules impose stricter requirements and limitations on biosolids land application, especially for Class B biosolids. This was especially observed with decreases Class B land application permits in recent years. For Class AA biosolids there seems to be potential agricultural and commercial markets for biosolids products in the region surrounding Broward County. The team found that there is a reasonable amount of agricultural acreage to support a biosolids land application program, but also a strong presence of landscape businesses that could offer a more diverse and resilient market for Class AA biosolids products. The final step in data development was the evaluation of data from the 11 participating Utilities as well as the future growth and potential increase of solids produced.

During alternatives analysis, the team used the data collected previously to inform the key evaluations – technologies, sites, and delivery models. The team reviewed technologies with all of the participating Utilities and used different qualitative criteria to narrow them to the four that went on for further economic evaluation: thermal hydrolysis, thermal drying, composting, and fluidized bed incineration. During the workshop discussions, the RBS Workgroup decided to move forward with thermal drying.

Finally, the analysis introduced potential sites for the facility based on size and criteria needed for a thermal dryer facility. Additionally, governance tracks and different delivery models were introduced. No decisions were made on these items as they will be further explored in the next steps.

9.2 Recommended Technology – Thermal Drying

The team selected thermal drying as the recommended technology due to the following benefits:

- Proven technology with hundreds of successful installations in the U.S.
- Because there are several thermal dryer manufacturers and thermal dryer types, there is a vast range of initial capital costs associated with thermal drying projects. At this estimated dryer facility size the capital cost range can be $200M to $570M. This study was conservative using higher capital estimates including having thermal dryer redundancy.
- Ease of implementation. The participants visited the Palm Beach County regional thermal drying facility, which has been operating successfully, and were able to ask pertinent questions about the process from the beginning (interlocal agreements, etc.) to the end (construction completion and operation).
- Significant reduction in volume of solids during the thermal drying process as compared to THP while on a cost basis, the THP alternative appears to cost less than thermal drying, the volume reduction manifests itself in the hauling. For instance, in 2043, it is estimated that 91 and 42 trucks per year (at 20 tons per truck) would leave the facility for THP and thermal drying, respectively.
- From a market standpoint, thermal drying produces a sellable product. This product can be used in commercially at golf courses or residentially for home gardens. The type of product is dependent on the thermal dryer chosen.

- Natural gas consumption and number of units could be reduced by thinking outside the box by utilizing waste heat waste heat from the dryers or trying a new technology such as Elode.
- Finally, as part of the consideration for the thermal dryer selection, if the County had to pivot to address PFAS mitigation in sludge, the two most promising and commercially advanced technologies currently on the market, pyrolysis and gasification, require thermal drying as the initial step.

9.3 Next Steps Recommendations

As the project progresses into next steps, the participating members from the RBS Workgroup have a decision to make regarding further participation. As noted in Figure 9-1, the first step and off ramp is determining the participating partners with a memorandum of understanding (MOU). This MOU would signify the RBS Workgroup's intent on working towards an agreement and doing business together. The RBS Workgroup members that move forward are approximately 80 percent likely to continue with the regional facility, but this is not the last opportunity for a RBS Workgroup member to leave the project, this would occur with formal governance agreements. However, once a RBS Workgroup member leaves the project, re-entering will be more difficult (e.g. the regional facility may not have capacity, pricing is likely higher for late entrants, etc.) and will depend on the governance agreements. As noted below, the next step of the process can be completed in parallel: (1) conceptual design and (2) governance agreements.

Conceptual Design: During this project, a high-level evaluation was conducted to be able to compare costs among different alternatives. Now that a technology has been selected, a conceptual design can be developed to refine these costs. Once the RBS Workgroup members have been determined, new data should be collected from each RBS Workgroup member to reflect more recent operations. The total amount of solids and solids content does impact the overall sizing of the equipment. Further, our analysis only evaluated drum dryers, which, while best suited for large installations and generate the highest quality product, are expensive from both a capital and operations standpoint. A conceptual design can evaluate the other types of dryers on the market that could impact overall capital costs. A conceptual design would also refine costs, refine siting requirements, and permitting requirements. All of these can be part of the governance agreement discussions.

Governance Agreements: Section 8 describes some of the governance tracks that this project can take. Essentially, this step is when key decisions and contractual agreements are determined. Typically, the RBS Workgroup member's lawyers' are involved providing guidance on the types of contractual arrangements each RBS Workgroup member can enter. As part of this process, questions such as the following could be addressed:

- Who are the stakeholders?
- Who and how will future decisions be made regarding the regional facility?
- How will capacity be allocated to each Utility now and in the future?
  - If future capacity is allocated now, can a utility "sell" their unused capacity to another entity?
- What, if any, upfront fees does each RBS Workgroup member need to pay? How are fees and rates equitably determined?
- If a RBS Workgroup member hosts the facility on their site, do they receive host fees or a reduce rate?
- Can other Utilities join later? How is the rate determined for those Utilities?
- Who will be in charge of operating the facility?

Ultimately, this is when the RBS Workgroup members determine how they will organize themselves moving forward. This is the next off ramp time for RBS Workgroup members.

Delivery model: The next step in the process would be determining the delivery model. Specific delivery models may not be allowed under the agreements. Section 8.2 highlights the different project delivery approaches that could be employed. The three prominent project delivery methods are DBB, CMAR, and PDB. As noted below, this is the final step for an RBS Workgroup member to off ramp.

Site Selection: Depending on the delivery model selected as well as the refined information from the conceptual design and guidance from the governance documentation, sites can be narrowed and selected, which best fit the RBS Workgroup members' selection criteria. Sites can be narrowed and selected in parallel with the delivery model selection. Finally, the RBS Workgroup members are signing contracts to proceed with the Regional Facility as outlined in their agreement. A request for proposals would be issued on behalf of the RBS Workgroup based on the delivery model selected. Finally, the facility would be designed and constructed with operational control based on governance determined previously.

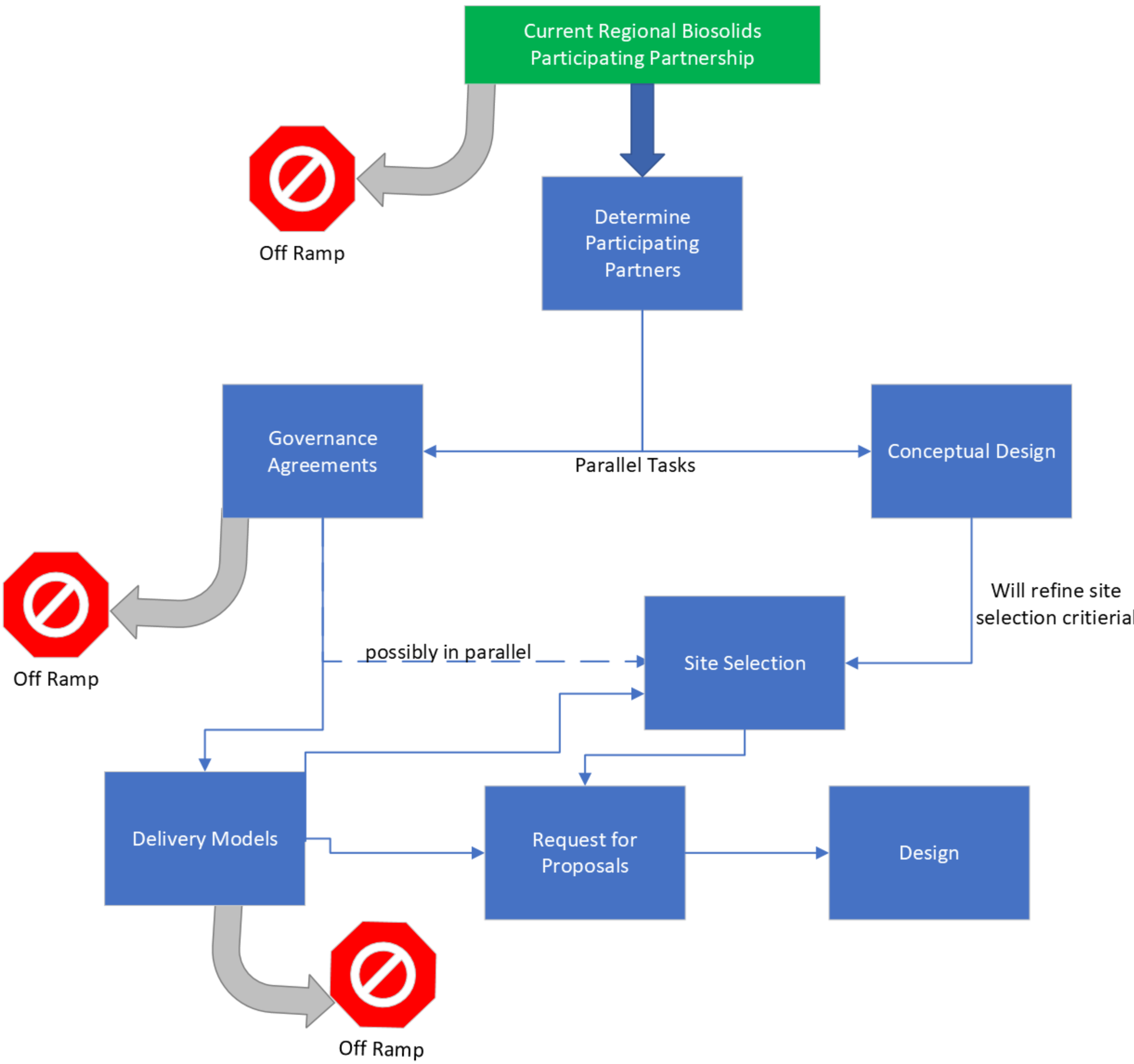


Figure 9-1. Next steps flow chart.

References

Barker, M. (2021). *Chapter 62-640, FAC Public Meeting Division of Water Resource Management*.

Basic Information about Biosolids. (2023). United States Environmental Protection Agency. https://www.epa.gov/biosolids/basic-information-about-biosolids

Biosolids Laws and Regulations. (2023, June 20). United States Environmental Protection Agency. https://www.epa.gov/biosolids/biosolids-laws-and-regulations#standards

DEP Chapter 62-640, F.A.C., Rulemaking. (2023). Florida Department of Environmental Protection. https://floridadep.gov/water/domestic-wastewater/content/dep-chapter-62-640-fac-rulemaking

Hallas, J., Mackowiak, C. L., & Wilkie, A. C. (2019). *Florida Biosolids: Management and Land Application Rules 1 Introduction and Purpose*. https://edis.ifas.ufl.edu/

Resek, E. (2021). *EPA Biosolids Program 40 CFR Part 503 Biosolids Part 1: Overview of Wastewater Treatment Sludge and Clean Water Act Regulatory Structure Practice*.

Truitt, J. (2019). *Biosolids in Florida Presentation to Senate Committee on Environment and Natural Resources*. Florida Senate.

Walker, J., Knight, L., & Stein, L. (1994). *A Plain English Guide to the EPA Part 503 Biosolids Rule.*

Young, S. D. (2023). *Discount Rates For Cost-Effectiveness, Lease Purchase, And Related Analyses*. www.whitehouse.gov/wp-content/uploads/legacy_drupal_files/omb/circulars/A94/a094.pdf

Attachment A: Workshop Presentations

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

May 24, 2023

Agenda

- Welcome and Introductions
- Project Overview
  - Project Background
  - Project Plan and Decision-Making Framework
- Alternative Evaluations
  - Technology
  - Site assessment
  - Delivery model
- Project Scope, Schedule and Timeline
- Technology Review (if time)
- Next Steps

Welcome and Introductions

Name	Organization
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Celia Earle	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Marie Burbano	Brown and Caldwell
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Mark Drummond	C Solutions
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale

Name	Organization
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise

Project Overview

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Project Phases

- Phase 1 – Data Development
  - Compilation, analysis, and summary of key data
- Phase 2 – Regional Planning Alternatives Analysis
  - Evaluation of data and development of a regionalization plan
- Phase 3 – Future Phase (to be determined)
  - Based on Phases 1 and 2, determine whether further analysis of a regional Facility/Facilities is warranted

Overall Project Plan

– Structured, cooperative framework that results in decisions that are transparent and defendable with consensus

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- Planning document aligned with Team expectations and future vision

Phase 1 (Data Gathering and Analysis)

Phase 2 (Alternatives Evaluations; Regional Biosolids Plan)

Data Request

- Request sent for review on 5/5/23
- Received data from
  - Coral Springs Improvement District
  - City of Margate
  - Broward County
  - Town of Davie
- Need remaining 7 utilities
- Are there any questions on the data request?
- Can all data be received by June 9th?

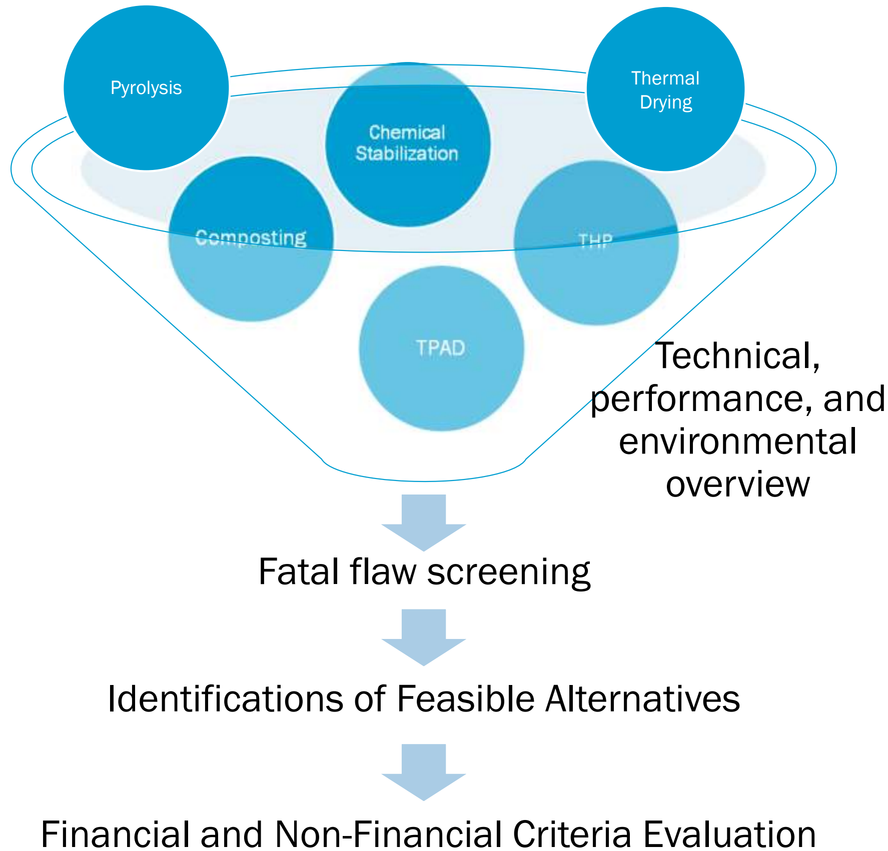
Item Requested
1. Any summary or planning document that provides an overview of the current solids' operation and/or plans for future investments.
2. Three years' worth of sludge/biosolids operation (from raw sludge production in primaries or activated sludge, through thickening, other-processing, dewatering, and trucks being "sent out the door"); and any/all related laboratory data. a. If you do not regularly collect total (TS or TSS) or volatile solids (VS or VSS) data, we request that you grab and test at least three samples of each sludge along your process for TS and VS.
3. Most recent, fully completed fiscal year of budgeted and performance-against-budget for solids-related costs. This should include, thickening, dewatering, or other process O&M, polymer, or other chemical addition/use, and contracted services (likely for hauling/disposition).
4. Assessment (even if a current guess) as to the useful life of any process unit equipment, tankage, or other infrastructure that is needed for solids treatment. a. If you have Capital Improvements planned and budgeted, please share estimated costs and descriptions for those.
5. Summary of Power-cost rate structure and current power unit costs. And an estimate of average power use for solids handling (likely in either kW or MW).
6. If natural gas or other fuels are used for solids handling, please provide your average unit costs and usage.
7. Other pertinent/related information for consideration.

Alternative Evaluation Process

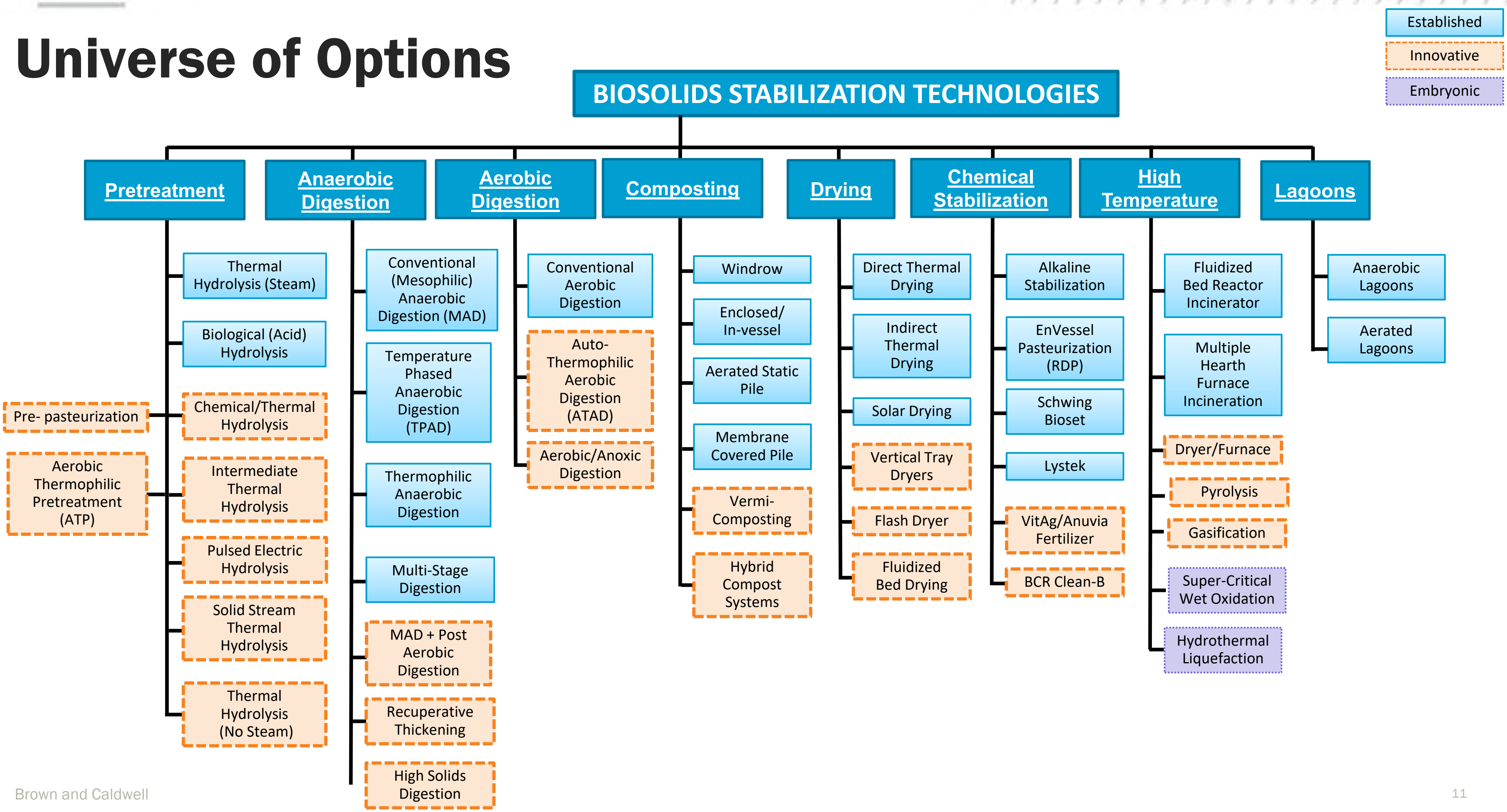
Brown AND Caldwell

Technology Evaluation – Screening of Universe

- Development of transparent and defendable documentation
- Examples of Fatal Flaw Criteria
  - Produces Class A or AA product
  - Footprint
    - The technology fits within a given footprint
  - Technology status (e.g. embryonic, proven, at least 1 commercial installation, etc.)
- *Technology Evaluation to be evaluated in Tasks 2.1 and 2.2*

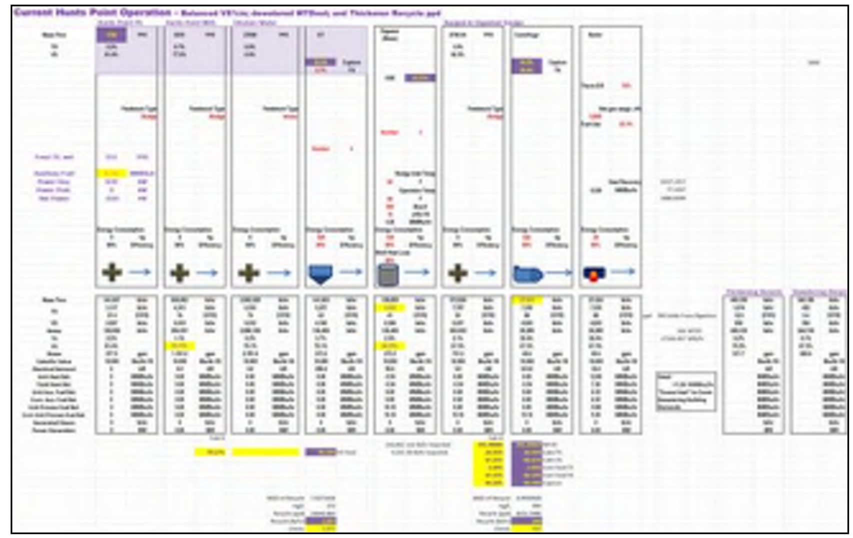


Universe of Options



Technology Review – Financial Criteria Using SWEET

- Use Solids Water Energy Evaluation Tool (SWEET) model to evaluate solids processes for high-level sizing and life-cycle cost evaluations
- SWEET tracks:
  - Total and volatile solids
  - Water content
  - Thermal and electricity demands
  - Fuel, heat, and electricity production
- SWEET overview
  - Evaluates multiple options and provides life-cycle cost information
  - Can be used "live" in workshops
  - Allows criteria input with implications changes immediately apparent-sensitivity analysis



One "SWEET Scenario"

SWEET DEMO

Technology Review – Non-Financial Criteria

- Decision criteria identified, defined, and defined with input from the team
- Goal to reach consensus for collaborative decision-making

Step 1: Develop Criteria List

Criteria List
Criterion #1
Criterion #2
Criterion #3
Criterion #4
Criterion #5
Criterion #6
Criterion …

Step 2: Criteria Refinement

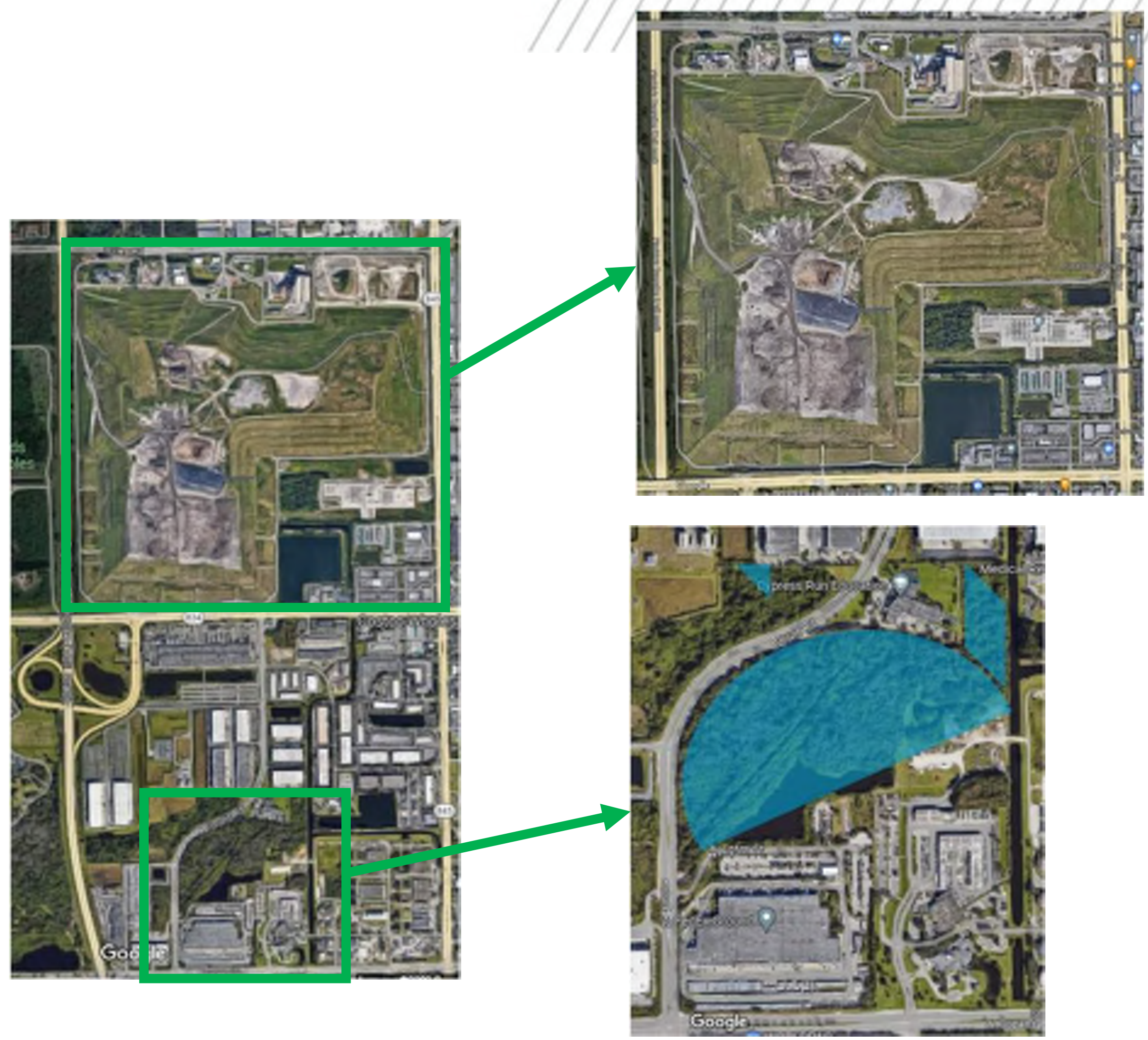
Criteria List
Flexibility for the Future
Reliability
Achieves Class A
Operation Complexity
Community Impacts
Regulation Challenges
Odors

Step 3: Criteria Scoring Methods

- Quantitative or qualitative?
- What differentiates alternatives?
- How do alternatives rank in terms of criteria?

Site Assessment

- Two initial sites for consideration
  - North of Administration
  - Possibly at Landfill
- Opportunities for other sites to be considered
- *Site assessment to be completed in Task 2.3*



Delivery Model Alternatives

- Four potential tracks for implementation of a regional biosolids management approach are being suggested:
  - Track 1 — Utility Control
  - Track 2 — Participation in an Existing Regional System
  - Track 3 — Public / Private Partnership
  - Track 4 — Privatization
- *Delivery Model Alternatives to be evaluated in Task 2.4*

Project Scope, Schedule, and Timeline

Phase 1 – Data Development

1.1 Evaluation of Existing Conditions

- 1.1.1 Biosolids Quantities and Characteristics (see data request, next slide)
- 1.1.2 Biosolids Management Studies/Practices by Neighboring Utilities
  - Miami-Dade Water and Sewer Department, the Palm Beach County Solid Waste Authority, St Lucie County, the City of Hollywood, Broward County and others.
  - Review and summarize plans

1.2 Projection of Future Conditions

- 1.2.1 Biosolids and Residuals Quantities and Characteristics
- 1.2.2 Biosolids Forecast

<u>Meetings for Tasks 1.1 and 1.2</u>

Meeting #1 (May): Kickoff, Data request
Meeting #2 (July): Data analysis summary, Projection of Future Conditions

Phase 1 – Data Development (continued)

1.3 Evaluation of Rules and Regulations

- Regulatory outlook on federal and state level
- Potential regulations especially for end-use practices and PFAS
- Potential support for regional solutions including recent state legislation and grant funding

1.4 Preliminary Market and Value Chain Review

- Market Study to estimate economics of reuse of Class A or B or other products
- Review FDEP Database on Biosolids Use Practices
- Existing Distributors of Biosolids Products review (up to 3 distributors)
- High Level Assessment of Potential Value-Added Revenue Generating Options (biogas)

Meeting for Tasks 1.3 and 1.4

Meeting #3 (September): Review of Rules and Regulations, Market Assessment, and High-Level Technology Screening to select down to up to four (4) to be included in further analysis

Task 2 – Regional Planning Alternatives Analysis

2.1 Technology Alternatives Analysis

- Provide technical, performance and environmental information

2.2 Alternatives Analysis: Solids Water Energy Evaluation (SWEET) Model

- Model up to four (4) alternatives at high level with SWEET to obtain screening level net present value, O&M considerations and biosolids and residual volumes
- Order of magnitude alternative cost estimates
- Non-financial criteria impacts and benefits to facilitate decision making

<u>Meetings for Tasks 2.2</u>

Meeting #4 (October): High level alternatives analysis for up to four (4) alternatives using SWEET model, select two (2) for further consideration

Meeting #5 (December): Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost

Task 2 – Regional Planning Alternatives Analysis
(continued)

2.3 Site Assessment Alternatives

- 2.3.1 Determine Site Requirements
- 2.3.2 Local Sites –Two (2) sites initially identified for consideration

2.4 Delivery Model Alternatives – Review four (4) potential tracks for regional management approach

2.5 Recommendations for Phase 3 Study

2.6 Regional Biosolids Plan Report – draft and final

– Draft to be delivered ~March 2024

Meetings for Tasks 2.3 through 2.6

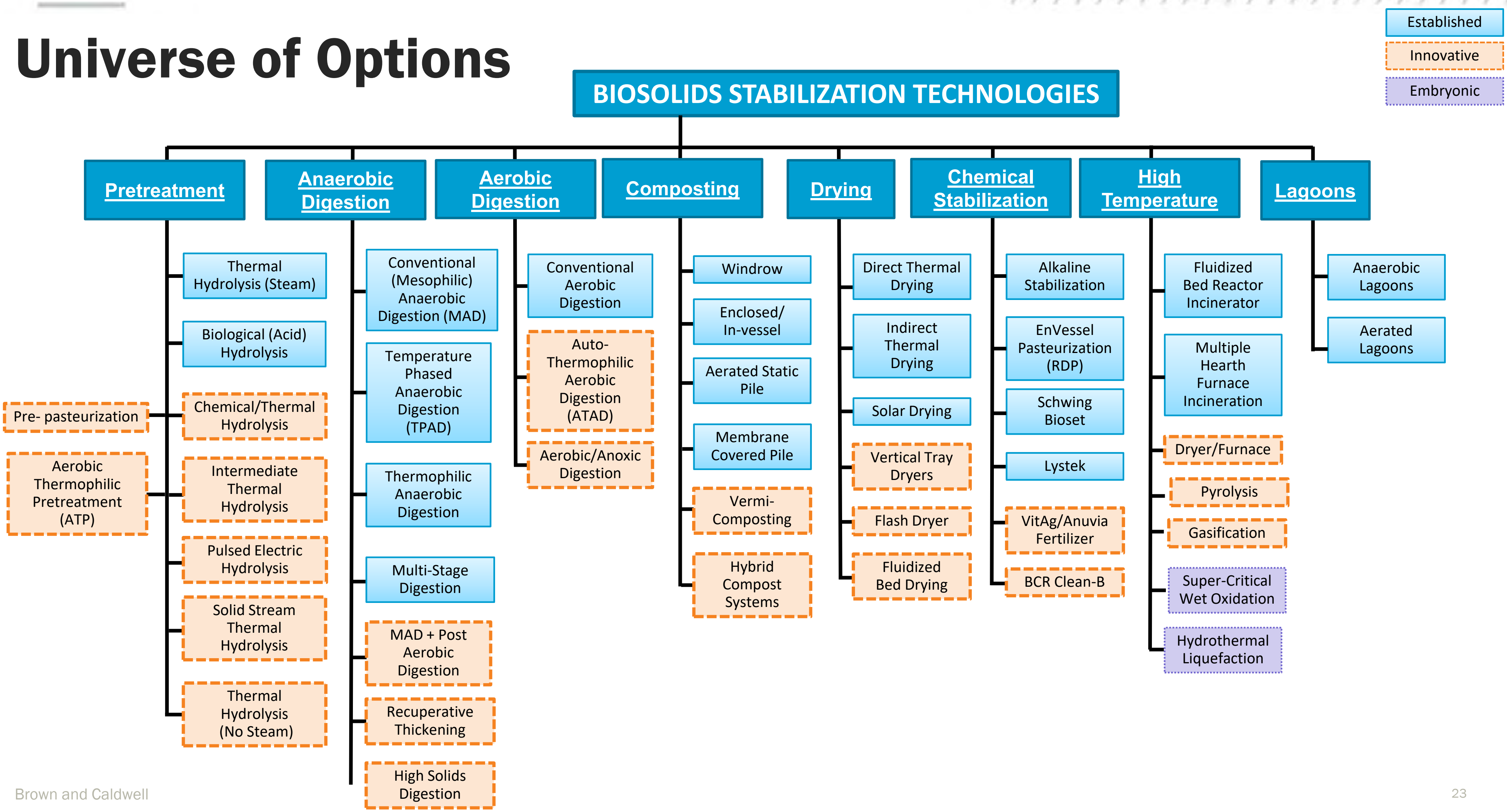
Meeting #6 (February): Site assessment and delivery models
Meeting #7 (April): Phase 3 Recommendations & Report Review

Project Schedule and Timeline

- NTP – May 4, 2023
- Task 1 duration – 6 months
- Task 2 duration – 6 months
- Seven (7) two-hour meetings expected – underlined request in-person
  - Meeting #1 (May): Kickoff, Data request
  - Meeting #2 (July): Data analysis summary, Projection of Future Conditions
  - Meeting #3 (September): Review of Rules and Regulations and Market Assessment
  - Meeting #4 (October): High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration
  - Meeting #5 (December): Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost
  - Meeting #6 (February): Site assessment and delivery models
  - Meeting #7 (April): Phase 3 Recommendations & Report Review
- Meetings will be Wednesdays in the afternoon (2PM), propose 2 hours each

Technology Review

Universe of Options



Chemical Stabilization

- Low capital option, temporary units available
- Popular product with farmers
- More volume to manage than destruction technologies
- Odors and worker safety are concerns
- Provides Class B biosolids
- Alternative Processes
  - Post Lime Stabilization
  - N-Viro Soil Process
  - Bioset

Composting

- Biosolids are blended with a carbonaceous feedstock like wood chips – good solution for utilities managing multiple waste streams
- Simple to operate & maintain
- Can easily accommodate sludge from different sources (very forgiving)
- Generates a product suitable for local use
- Produces Class A biosolids
- Alternative Processes
  - Aerated static pile
  - Windrow
  - Aerated windrow
  - Membrane covered pile
  - Hybrid compost systems
  - In-vessel

Thermal Conversion & High Temperature Combustion

- Produces Class A or Class-AA biosolids
- Alternative Processes
  - Biological hydrolysis
  - Thermal hydrolysis
  - Incineration with heat recovery

Temperature Phased Anaerobic Digestion (TPAD)

- Set up with Thermophilic tank followed by Batch Tanks
- Cooling for ‘polishing step’ to decrease odors
- Cooling is a struvite challenge
- TPAD offers benefits:
  - Improves gas production with less biosolids
  - Can be fed dewatered sludge better for regionalization
  - Class-AA cake dewaters to 30% with BFPs for fewer wet tons
  - Increases digester capacity by ~50%

Since 2019, Regional, Sewer-Consolidated, Class-A TPAD with Digester Gas Upgrading has operated at St. Petersburg.

Thermal Hydrolysis

- Use heat and pressure to enhance sludge digestion and stabilization
  - THP – Thermal Hydrolysis Pretreatment (Cambi process)
- THP is pre-digestion/sterilization system which greatly reduces viscosity of the sludge
- Benefits:
  - Pre-sterilizes sludge before digestion
  - Digests WAS better for more gas and fewer biosolids
  - Can be fed dewatered sludge (better for regionalization)
  - Class-AA cake dewaters to 30% with BFPs for fewer wet tons
  - Increases digester capacity by ~50%, allows double the loading to digesters
- Both PS and TWAS are sent through THP for Class A projects

Cambi B6-4 provides Class-A pretreatment of sludge from 60mgd for Hampton Roads Sanitation District (VA)

Thermal Drying

- Ideal when hauling or end use costs are high – significant volume reduction
- Typically digest and dewater first
  - Unless WAS only and then dewater only
- High quality pellets can help diversify end use/access non-agricultural markets
- Can be fueled by biogas, natural gas, or electricity
- Finished product is typically Class A, >90% TS
- Major thermal drying technologies:
  - Rotary Drum Dryers
  - Vertical Thin Film Dryers
  - Jacketed Hollow-Flight Dryers
  - Fluid Bed Dryers

Next Steps

Brown AND Caldwell

Next Steps

- Obtain data – due June 9th
- Data review and model setup
- Meeting #2 (July 26, 2-4pm, MS Teams): Data analysis summary, Projection of Future Conditions
- Meeting #3 (September 20, 2-4pm, MS Teams): Review of Rules and Regulations and Market Assessment

Thank you.

Questions?

Brown AND Caldwell

Brown AND Caldwell

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

July 26, 2023

Agenda

- Welcome
- Health & Safety Minute
- Project Overview
- Data Review
  - Summary of Current Facilities' Data
  - Solids Projections
  - Assumptions for analysis
  - Biosolids in Florida
- Screening Criteria
  - Technology Screening
- Next Steps

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Safety Minute

- Emergency exits and rest rooms
  - Make yourself aware of the nearest emergency exit to you

Project Overview

Brown AND Caldwell

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are transparent and defendable with consensus

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- Planning document aligned with Team expectations and future vision

Phase 1

Phase 2

Project Schedule and Timeline

- NTP – May 4, 2023
- Task 1 duration – 6 months
- Task 2 duration – 6 months
- Seven (7) two-hour meetings expected
  - ~~Meeting #1 (May): Kickoff, Data request~~
  - Meeting #2 (July): Data analysis summary, Projection of Future Conditions
  - Meeting #3 (September): Review of Rules and Regulations and Market Assessment
  - Meeting #4 (October): High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration
  - Meeting #5 (December): Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost
  - Meeting #6 (February): Site assessment and delivery models
  - Meeting #7 (April): Phase 3 Recommendations & Report Review

Data Review

Current Data

Projected Data

Assumptions

Biosolids in Florida

Brown AND Caldwell

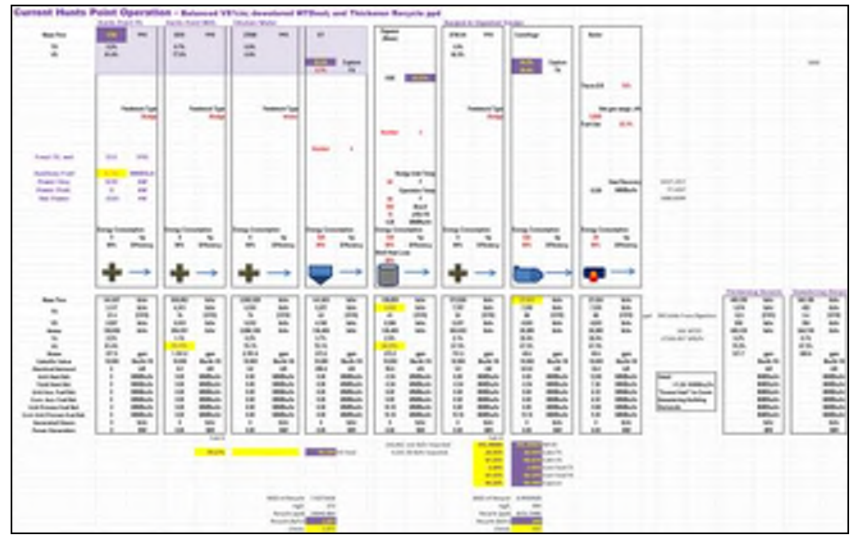
Data Request and Analysis

- Request for data sent in May 2023
- Received data from all 11 utilities
- Compiled into summary of dry and wet tons of solids per day, percent solids, hauling fee, and stabilization process

Item Requested
1. Any summary or planning document that provides an overview of the current solids' operation and/or plans for future investments.
2. Three years' worth of sludge/biosolids operation (from raw sludge production in primaries or activated sludge, through thickening, other-processing, dewatering, and trucks being "sent out the door"); and any/all related laboratory data. a. If you do not regularly collect total (TS or TSS) or volatile solids (VS or VSS) data, we request that you grab and test at least three samples of each sludge along your process for TS and VS.
3. Most recent, fully completed fiscal year of budgeted and performance-against-budget for solids-related costs. This should include, thickening, dewatering, or other process O&M, polymer, or other chemical addition/use, and contracted services (likely for hauling/disposition).
4. Assessment (even if a current guess) as to the useful life of any process unit equipment, tankage, or other infrastructure that is needed for solids treatment. a. If you have Capital Improvements planned and budgeted, please share estimated costs and descriptions for those.
5. Summary of Power-cost rate structure and current power unit costs. And an estimate of average power use for solids handling (likely in either kW or MW).
6. If natural gas or other fuels are used for solids handling, please provide your average unit costs and usage.
7. Other pertinent/related information for consideration.

Technology Review – Financial Criteria Using SWEET

- Use Solids Water Energy Evaluation Tool (SWEET) model to evaluate solids processes for high-level sizing and life-cycle cost evaluations
- SWEET tracks:
  - Total and volatile solids
  - Water content
  - Thermal and electricity demands
  - Fuel, heat, and electricity production
- SWEET overview
  - Evaluates multiple options and provides life-cycle cost information
  - Can be used “live” in workshops
  - Allows criteria input with implications changes immediately apparent-sensitivity analysis



One “SWEET Scenario”

Refresher from Kick-Off Presentation

Current Facilities Data

Data Summary (average 2020-2022)					
Region	**Total Solids (wtpy)**	**Total Solids (dtpy)**	**% TS**	**Hauling & Tip fee($/wt)**	**Additional Stabilization Treatment**
Broward County	94,911	14,833	15.63%	$44.48	Anaerobic Digestion
Cooper City	3,668	491	13.40%	$37.90	Aerobic digestion
Coral Springs Improvement District	2,546	308	12.10%	$64.00	Aerobic digestion
Town of Davie - System ll	2,697	337	12.48%	$55.47	Aerobic digestion
Town of Davie - System IV WRF	992	110	11.05%	$55.47	Aerobic digestion
Fort Lauderdale	29,457	5,150	17.48%	$63.36	Aerobic digestion
Hollywood	39,656	11,503	29.01%	--	Lime stabilization
City of Margate	4,016	657	16.37%	--	Rotating Biological Contactors (RBC)
City of Miramar	14,130	1,707	12.08%	$37.90	Anaerobic Digestion
Pembroke Pines	3,028	485	16.00%	$58.41	Aerobic digestion
Plantation	1,051	129	12.24%	--	Anaerobic Digestion
City of Sunrise - Sawgrass	10,050	1,811	18.02%	$61.43	Aerated sludge holding tanks
City of Sunrise - Springtree	3,470	680	19.59%	$61.32	Aerated sludge holding tanks
Total	209,672	38,200	18.22%	$50.82	

Solids Projections

Projected Solids in 2043			
JURISDICTION	Wet Solids (wtpy)	Dry Solids (dtpy)	% Change 2023-2043
BROWARD COUNTY	-	-	
Broward County	103,660	16,200	9.22%
Cooper City	3,730	500	1.74%
Coral Springs Improvement District	2,810	340	10.38%
Town of Davie - System ll	3,040	380	12.88%
Town of Davie - System IV WRF	1,090	120	9.43%
Fort Lauderdale	36,550	6,390	24.08%
Hollywood	33,090	9,600	14.40%
City of Margate	4,640	760	15.62%
City of Miramar	15,480	1,870	9.58%
Pembroke Pines	3,190	510	5.25%
Plantation	1,230	150	16.59%
City of Sunrise - Sawgrass	10,710	1,930	6.57%
City of Sunrise - Springtree	3,680	720	5.93%
Total	222,900	39,470	12.49%

Solids used for annual O&M costs

Cost Assumptions for Use in Model

- Polymer: $1.35/active lbs
- Electricity (blended rate): $0.083/kWh
- Hauling & Tip Fee: $50
- Average Labor (incl benefits): $55/hr
- Natural Gas: FPU GS-6 rate schedule (blended rate): $1.87/therm

Assumptions for Use in Model

- Volatile Solids Content: 70%
- Escalation rate: 4.2%
- Discount rate: 2.2%
- Equipment O&M: 2% of equipment
- Peaking factor for sizing: +10% of Projected loads

Biosolids in Florida

Beneficial Use	• Fertilizer – Class AA • Land application – Class B
Non-Beneficial Use	• Landfilled
Major Haulers	• H&H, Synagro, Revinu Resource Recovery, Merrell Brothers, Greenfield Management Services

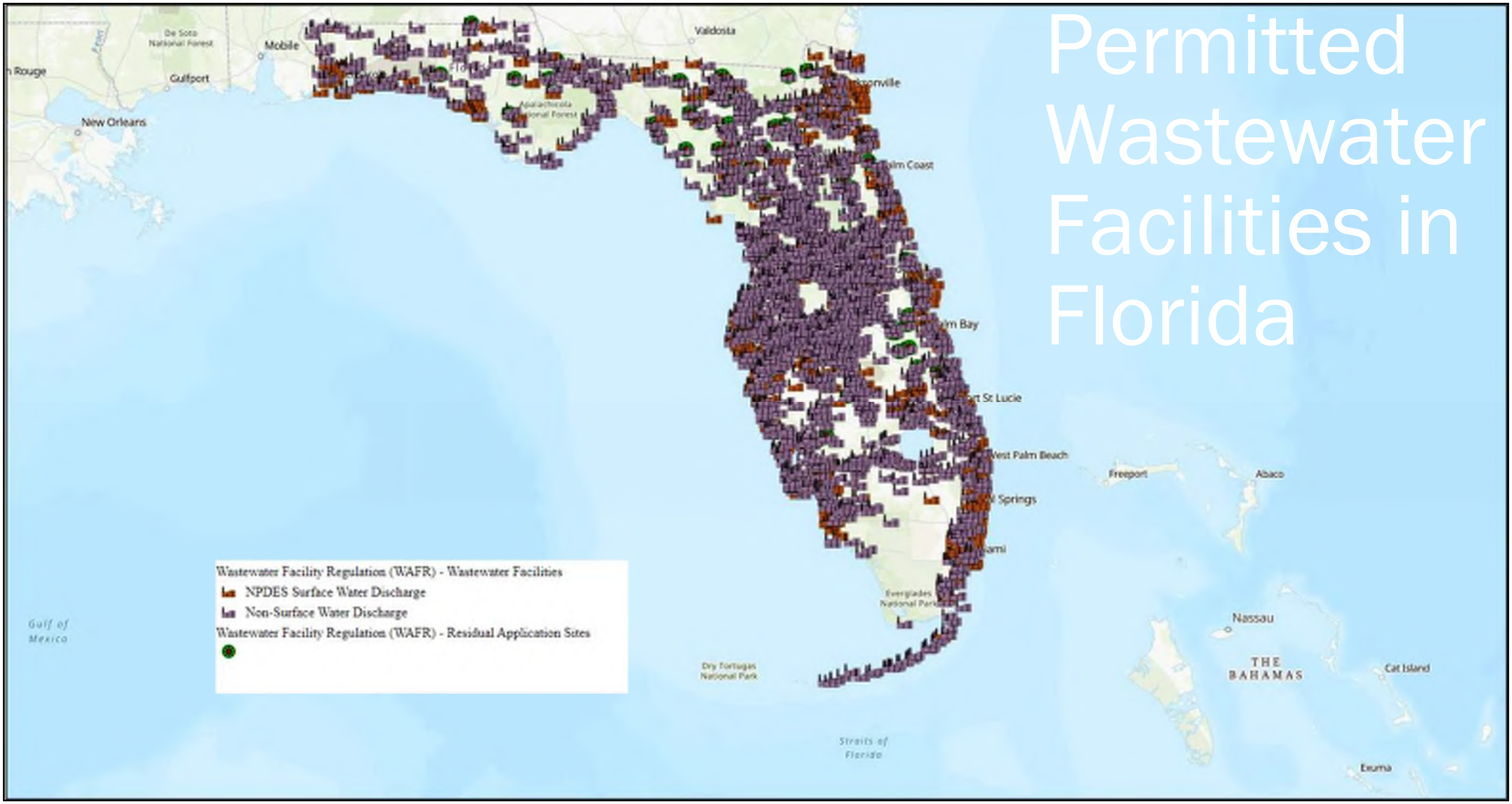
Class AA Biosolids

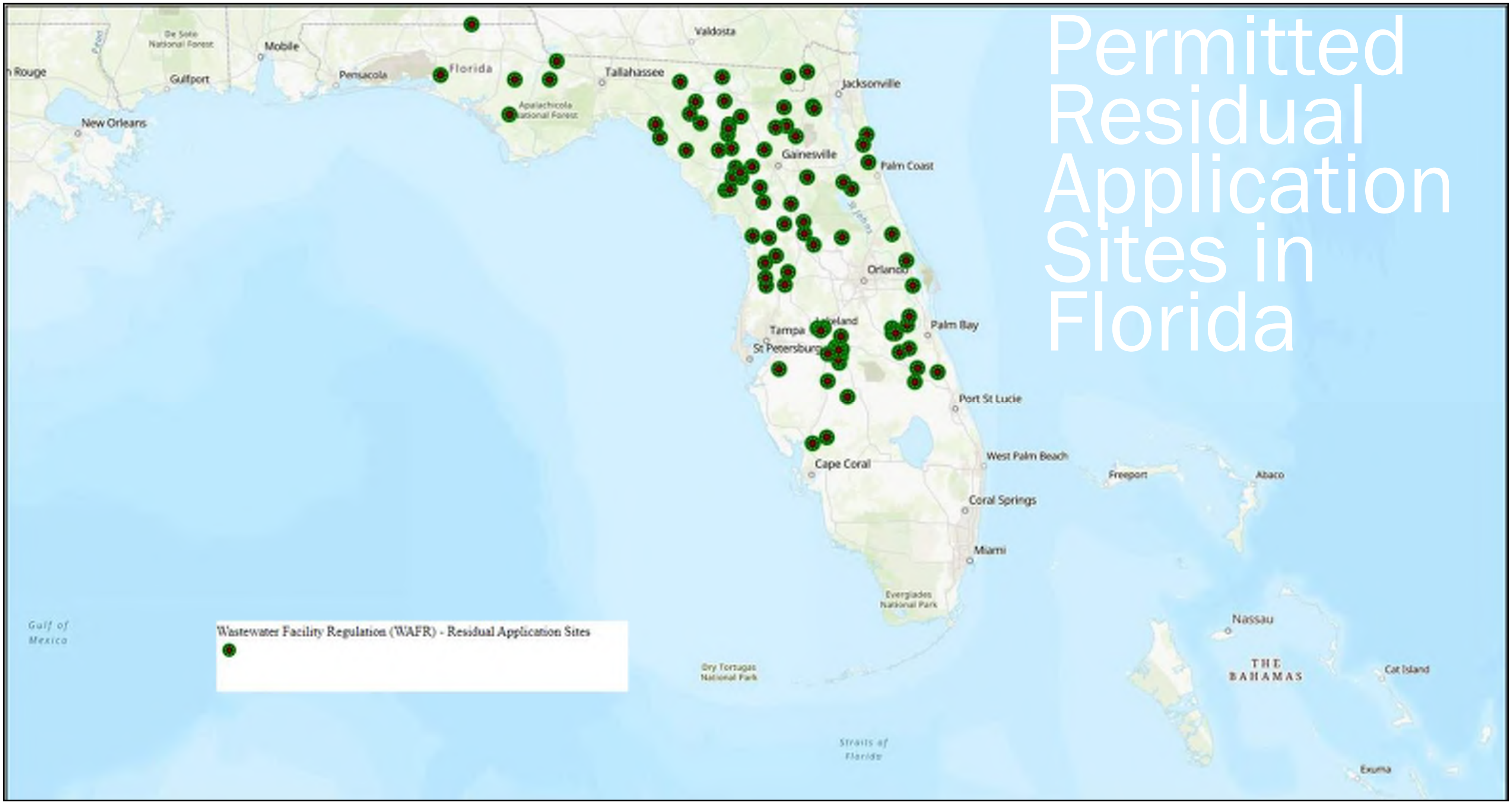
- Does not require a nutrient management plan
- Distributed and marketed as fertilizer or compost materials
  - Very few facilities in Florida product Class AA on site either with their own equipment or mobile units
  - Outside companies haul biosolids and then treat to Class AA off site

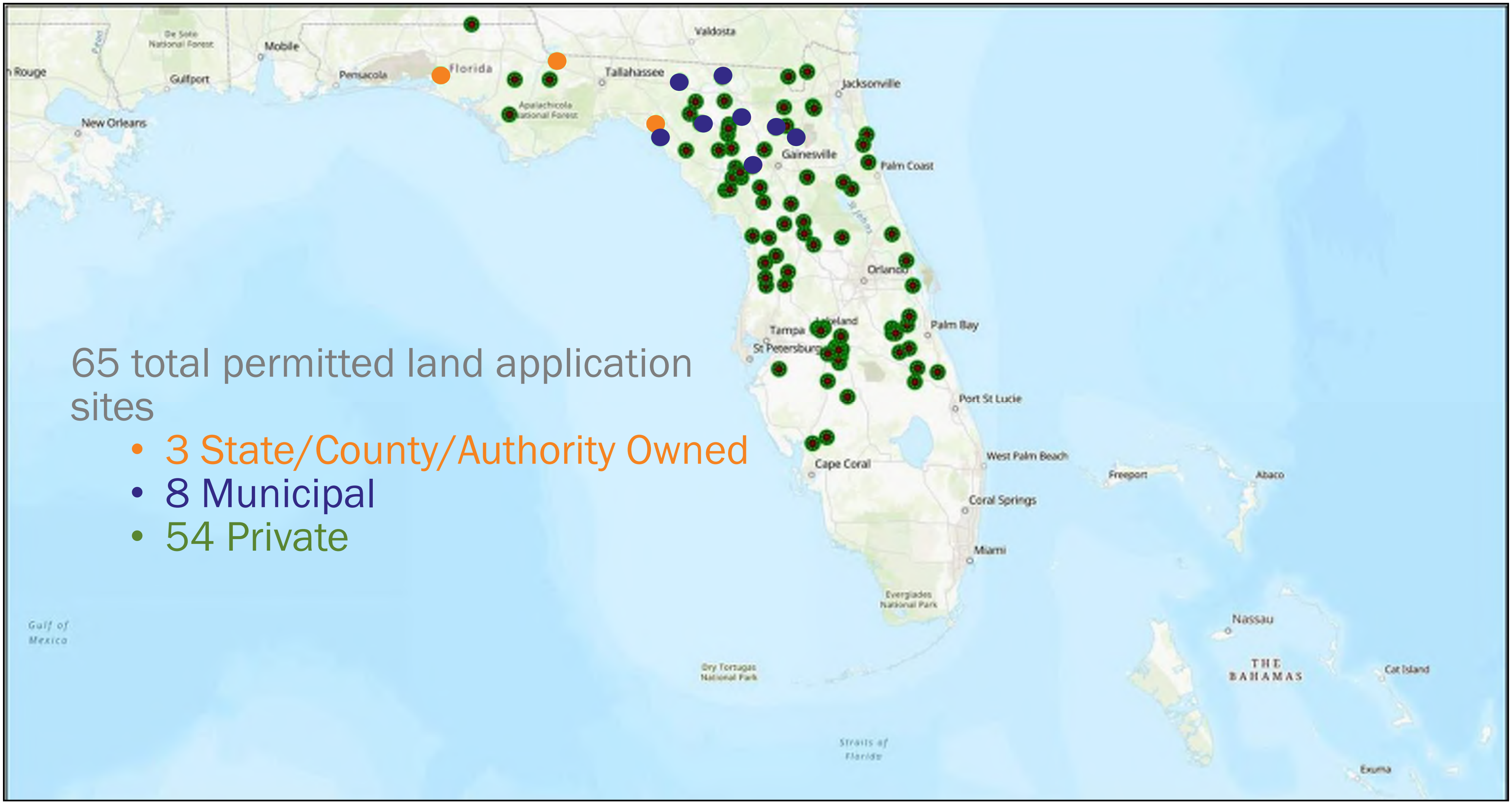
Class B Biosolids

- There are currently 65 permitted land application sites in Florida
  - 140 sites in 2019
  - Many are letting their permits expire with no intention of renewing
  - Most permits are held by haulers instead of a utility applying the biosolids themselves

Permitted Wastewater Facilities in Florida




Permitted Residual Application Sites in Florida
Wastewater Facility Regulation (WAFR) - Residual Application Sites
Valdosta
Mobile
Pensacola
Florida
Tallahassee
Jacksonville
Gulfport
New Orleans
Gainesville
Palm Coast
Orlando
Tampa
St Petersburg
Palm Bay
Port St Lucie
West Palm Beach
Cape Coral
Coral Springs
Miami
Freeport
Abaco
Nassau
THE BAHAMAS
Cat Island
Exuma
Gulf of Mexico
Straits of Florida



65 total permitted land application sites

- 3 State/County/Authority Owned
- 8 Municipal
- 54 Private

Facilities Comparison

Miami Dade Water and Sewer Department (WASD)

- **Number of Wastewater Facilities:** 3
  - North District, Central District, South District
- **Biosolids Produced:** Class B
- **Hauling Companies Used:** H&H, Revinu, and Synagro (future)
  - **Hauling Location:** Hauled to multiple facilities to produce Class A or AA
- **Hauling and Tip Fees:** $55/wet ton

SS0

Palm Beach County Water Utilities Department (WUD)

- **Number of Wastewater Facilities:** 4
  - Western Region, Western Region North, East Central Region, and Southern Region
- **Biosolids Produced:** Class B or Unclassified
- **Hauling Companies Used:** Synagro
  - **Hauling Location:** Solid Waste Authority of Palm Beach County
- **Hauling and Tip Fees:** $77/wet ton
- **Additional:**
  - Class AA Biosolids produced by NEFCO dryer with a capacity of 600 wet tons/day
  - Each partnering community that contributes to the facility has their own contracted amount for %TS

Screening Criteria

Why is Screening Important?

- Scope and schedule considerations
  - Detailed evaluation of every possible approach would take too much time without providing additional benefit

- Confirmation of all possible viable options
  - Documenting and brainstorming all possibilities confirms there are not good options we missed

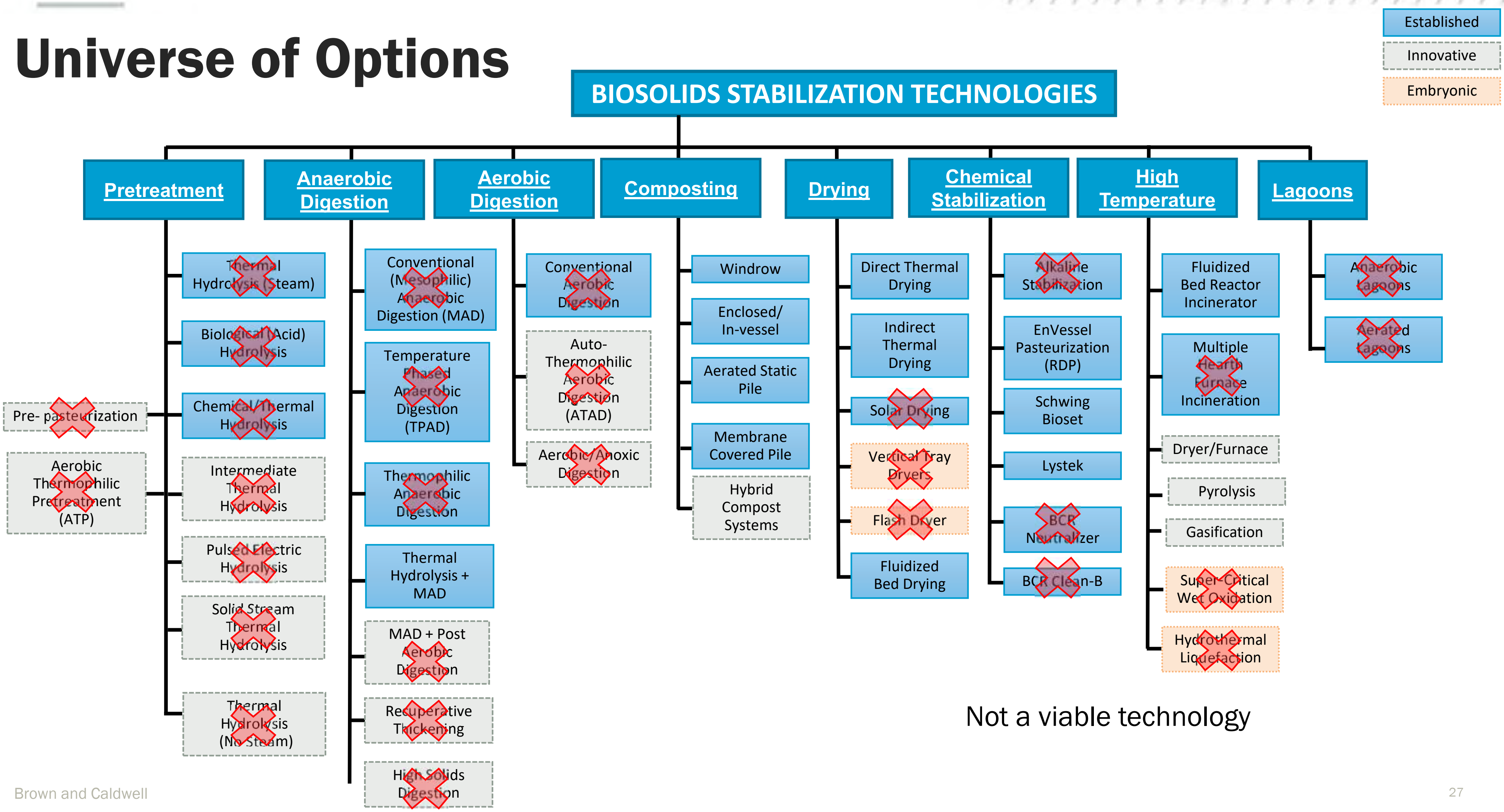
- Explanation for why some options were not evaluated
  - Tying screening to planning objectives provides concrete reasoning why an option wasn't considered viable

Screening Criteria versus Evaluation Criteria

- BC Pre-screened: Screened for pass/fail criteria (will review)
- Today: Screen to viable opportunities
- Future: Evaluate viable opportunities to determine which is preferred

- Screening criteria ➔ What we <u>must</u> have (non-cost only)
- Evaluation criteria ➔ What we <u>prefer</u> to have includes cost & non-cost criteria

Universe of Options



After pass/fail . . .

- THP with Mesophilic Digestion - PASS
- Composting
- Thermal drying - PASS
- ~~Lime stabilization (Schwing Bioset)~~
- ~~Thermal process (Pyrolysis)~~
- ~~Chemical stabilization (Lystek)~~
- Fluidized bed incineration
- Solar Drying

Regional Facility Non-Cost Goals/Objectives

- Create a diversity in biosolids/residue end use markets (Class AA product)
- Reduce biosolids volume
- Beneficially reuse biosolids and allow for resource recovery
- Provide flexibility and scalability to meet future regulations
- Ease of operation and maintenance
- Maintain or improve current carbon footprint
- Proven & reliable technology
- Minimizes footprint requirements to achieve objectives
- Minimizes neighborhood impacts (odors and traffic)
- Reduced regulatory oversight/paperwork
- Redundancy
- Permittable (including length of permitting time)

Group Name:

Non-cost Goals/Objectives	Weight (1 - 3)
Create a diversity in biosolids/residue end use markets (Class AA product)	
Reduce biosolids volume	
Beneficially reuse biosolids and allow for resource recovery	
Provide flexibility and scalability to meet future regulations	
Ease of operation and maintenance	
Maintain or improve current carbon footprint	
Proven technology	
Minimizes footprint requirements to achieve objectives	
Minimizes neighborhood impacts (odors and traffic)	

Discuss as a group how important these goals are to you and your utility. Each group will have one score.

Weight:

1 = Less important

2 = Important

3 = Most Important

Next Steps

Next Steps

- Market assessment and model setup
- Meeting #3 (September 20, 2-4pm): Review of Rules and Regulations and Market Assessment
- Future Meetings
  - Meeting #4 (October): High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration
  - Meeting #5 (December): Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost
  - Meeting #6 (February): Site assessment and delivery models
  - Meeting #7 (April): Phase 3 Recommendations & Report Review

Thank you.

– Questions?

Brown AND Caldwell

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

September 27, 2023

Agenda

Workshop 3: Review of Rules and Regulations and Market Assessment

- Welcome
- Health & Safety Minute
- Project Overview
- Workshop 3 Content
  - Task 1.1.2 – Biosolids Management Studies/Practices by Neighboring Utilities
  - Task 1.3 — Evaluation of Rules and Regulations
  - Task 1.4 — Preliminary Market and Value Chain Review
  - Task 2.1 – Technology Alternatives Analysis
- Next Steps

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Safety Minute – Snake Safety

To protect yourself and others, you should know how to:

- Describe snakes that live in your region
    - Venomous versus constrictor
- Avoid encounters with snakes
- Recognize snake bite signs and symptoms
    - Puncture marks at the wound
    - Redness and swelling
    - Severe pain at the bite site
- Respond if you or a companion are bitten
    - Move out of striking distance
    - Call 911
    - Be prepared to describe the snake's color and shape
        - <u>TAKE PHOTO if possible</u>
    - Assume a resting position, optimally with the affected area below heart level
    - The wound may be cleaned with soap and water using a damp cloth
    - The wound may be covered with a clean, dry bandage or dressing

Project Overview

Brown AND Caldwell

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are transparent and defendable with consensus

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- Planning document aligned with Team expectations and future vision

Phase 1

Phase 2

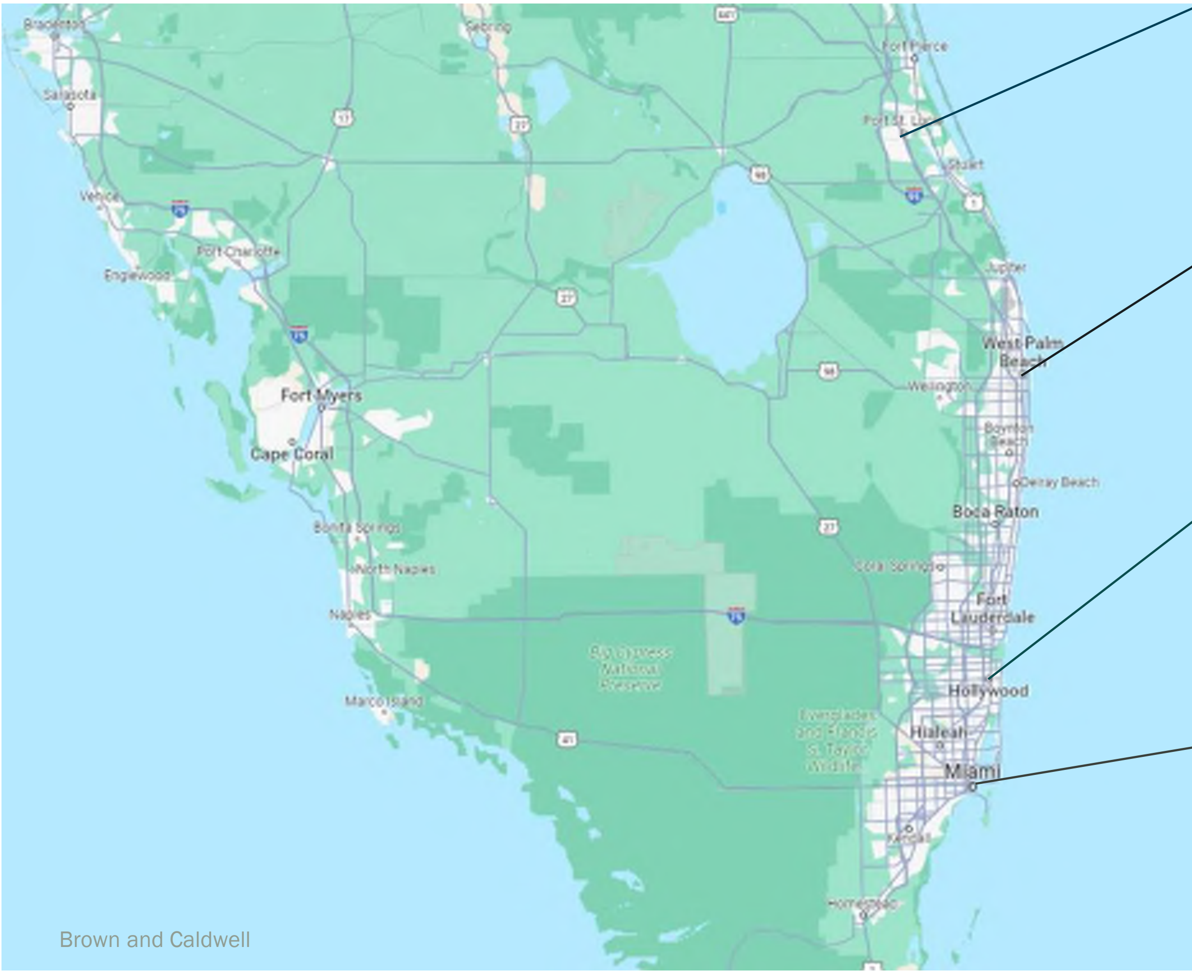
Project Schedule

Activity	Description	Date
NTP	Notice to Proceed	May 4, 2023
Meeting 1	Kickoff, Data Request	May 24, 2023
Meeting 2	Data analysis summary, Projection of Future Conditions	July 26, 2023
Meeting 3	Review of Rules and Regulations and Market Assessment	September 27, 2023, 2pm to 4pm
Meeting 4	High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration	November 1, 2023, 2pm to 4pm
Meeting 5	Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost	December 13, 2023, 2pm to 4pm
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 20, 2024
Meeting 7	Phase 3 Recommendations & Report Review (comments due on draft report)	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Biosolids Management Studies/Practices by Neighboring Utilities

Brown AND Caldwell

Communities of Interest



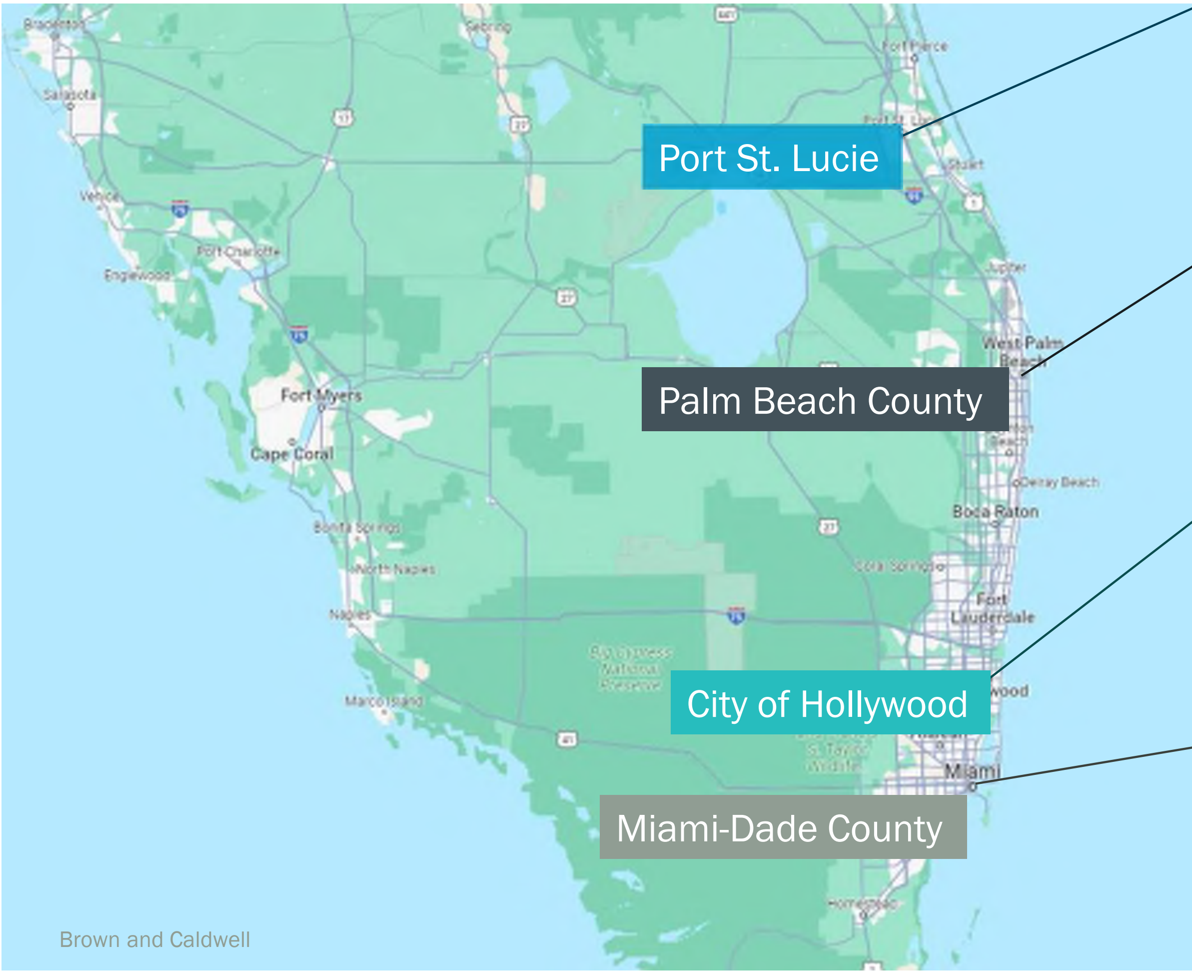
St. Lucie County

Palm Beach County

City of Hollywood

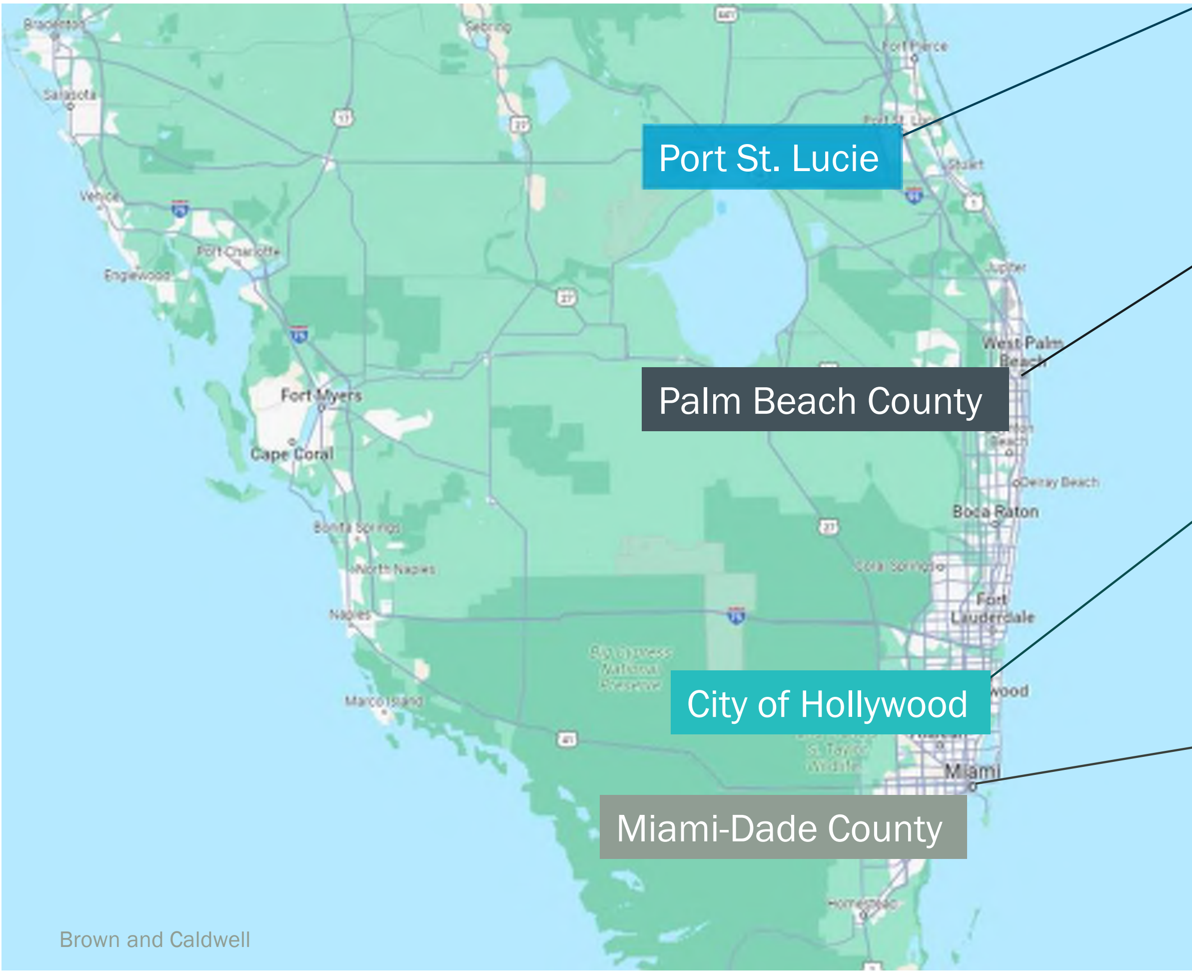
Miami-Dade County

Class of Biosolids Produced



- Unclassified
- Class B or Unclassified
- Class AA using Lime Stabilization Process
- Class B

Disposal/Beneficial Reuse



Composting

NEFCO Drying Facility at Solid Waste Authority

Sold as Fertilizer to Ranches

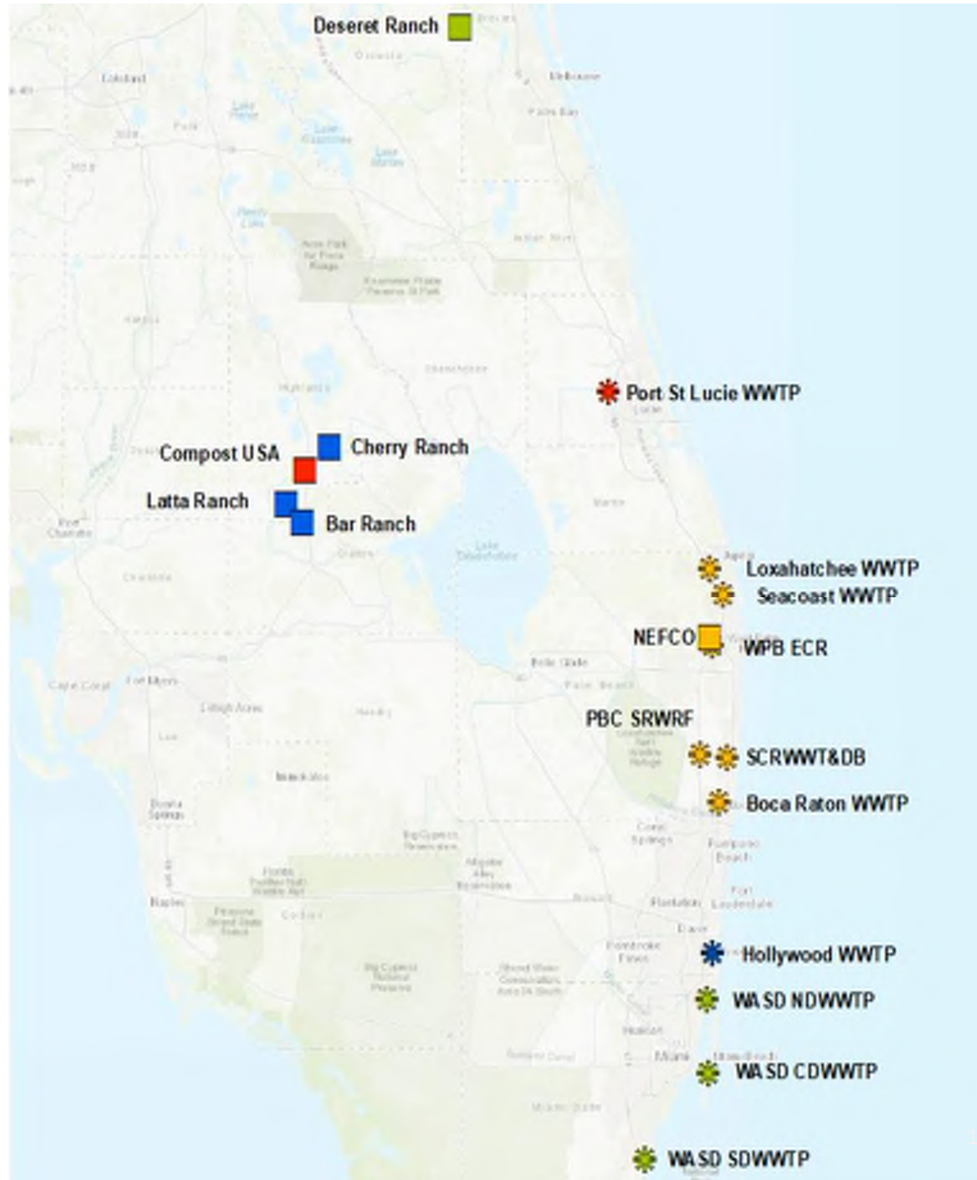
Land Application

St. Lucie County

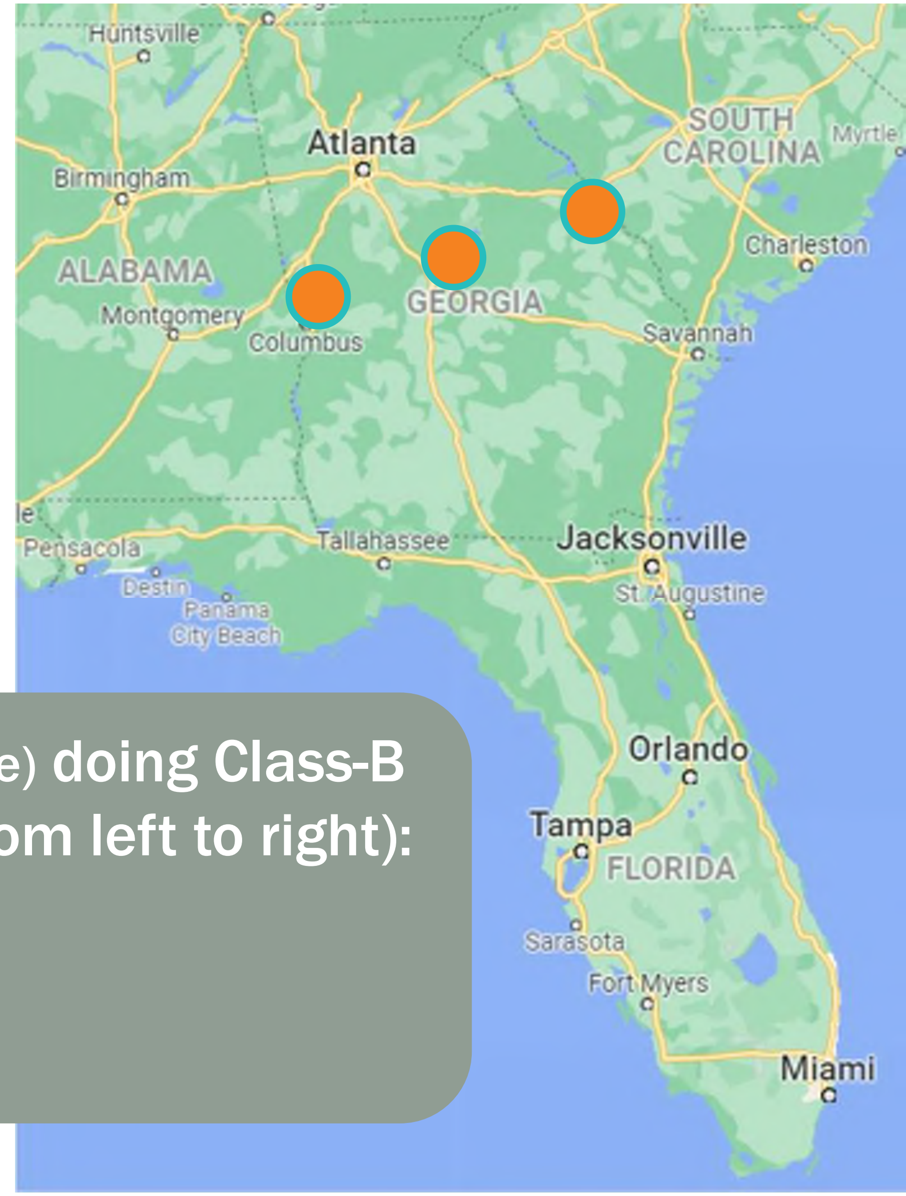
Palm Beach County

City of Hollywood

Miami-Dade County



Maps only raise more Questions…



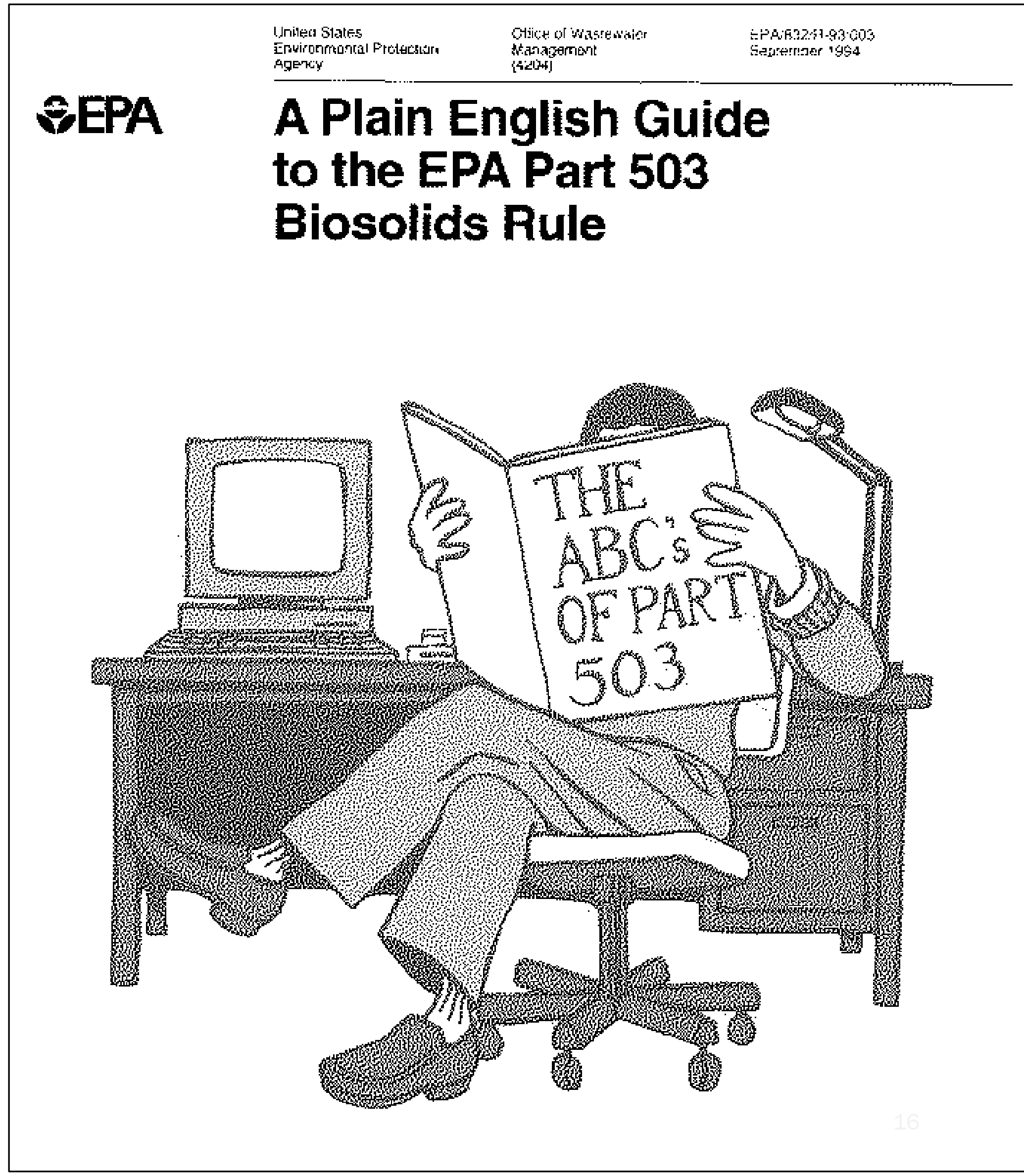
There are ONLY 3 utilities (to our knowledge) doing Class-B Biosolids Land Application in Georgia (from left to right):

- Columbus Water Works
- Macon Water Authority
- Augusta Utilities

Evaluation of Rules and Regulations

Federal Regulations

- *The Standards for the Use or Disposal of Sewage Sludge*
  - Title 40 of the Code of Federal Regulations (CFR), Part 503.
- An enforcement action can be taken against a WWTP that does not meet the requirements of Part 503 even there is no issued permit for the use or disposal of sewage sludge.
- Treatment facilities are required to submit annual reports on biosolids treatment and management practices by February 19th of each year.



State Regulations

Florida Administrative Code Chapter 62-640

Florida Statute 403.0855

House Bill 1309

Florida Statute 403.0674

State Regulations

- **Florida Administrative Code Chapter 62-640**
- Florida Statute 403.0855
- House Bill 1309
- Florida Statute 403.0674

– Primarily based on *Part 503*.

– The purpose of this chapter is to mitigate the threat that unregulated use, disposal, or land application of biosolids can pose to the environment and public health

– Applies to domestic wastewater treatment facilities, biosolids management facilities, distributors of biosolids or biosolids products, application sites which receive biosolids, septage management facilities that apply septage to sites, appliers of septage owners of application sites, and composting facilities that apply the compost to land

– Addresses the disposal of biosolids by landfill, monofill, surface impoundment, waste piling, incineration, co-composting with yard or bulking waste, and blending.

State Regulations

- Florida Administrative Code Chapter 62-640
- **Florida Statute 403.0855**
- House Bill 1309
- Florida Statute 403.0674

– Effective July 1, 2020. Comply by July 1, 2022.
– Permitted land application sites for biosolids must comply with two provisions:
  – Permittee of a biosolids land application site shall be enrolled in the Florida Department of Agriculture and Consumer Services (DACS) Best Management Practices program
  – Permittee of a biosolids land application site shall ensure a minimum unsaturated soil depth of 2 feet between the depth of biosolids placement and the water table level at the time the Class A/AA or Class B biosolids are applied to the soil.
– This statute does not allow for biosolids to be applied on soils that have a seasonal high water table less than 6 inches from the soil surface or within 6 inches of the intended depth of biosolids placement.

State Regulations

- Florida Administrative Code Chapter 62-640
- Florida Statute 403.0855
- **House Bill 1309**
- Florida Statute 403.0674

– The newest amendments to Chapter 62-640 were proposed as a part of House Bill 1309.

– Signed into law on June 21, 2021, **ratifying the proposed biosolids rules.** Requirements must be met by June 2023.

– The rule revisions were developed to **minimize the migration of nutrients**, specifically phosphorus, to prevent impairment to waterbodies.

– Highlights include:
  - **Rates of land application based on nitrogen and phosphorus**
  - **Total Nitrogen calculation formula change**
  - **Monitoring requirements for extractable phosphorus**
  - **Surface water monitoring requirements**

State Regulations

- Florida Administrative Code Chapter 62-640
- Florida Statute 403.0855
- House Bill 1309
- **Florida Statute 403.0674**

– Created to establish a biosolids grant program within the FDEP, starting July 1, 2023

– Authorizes the Department to **provide grants to counties and municipalities** that are working to implement innovative technologies for biosolids disposal and/or convert wastewater residuals to Class AA biosolids

– For a project to be eligible for funding, they must:

  – Reduce the amount of nutrients in biosolids;

  – Reduce the amount of emerging contaminants in biosolids; and/or

  – Provide alternatives to land application or landfilling as primary biosolids disposal methods.

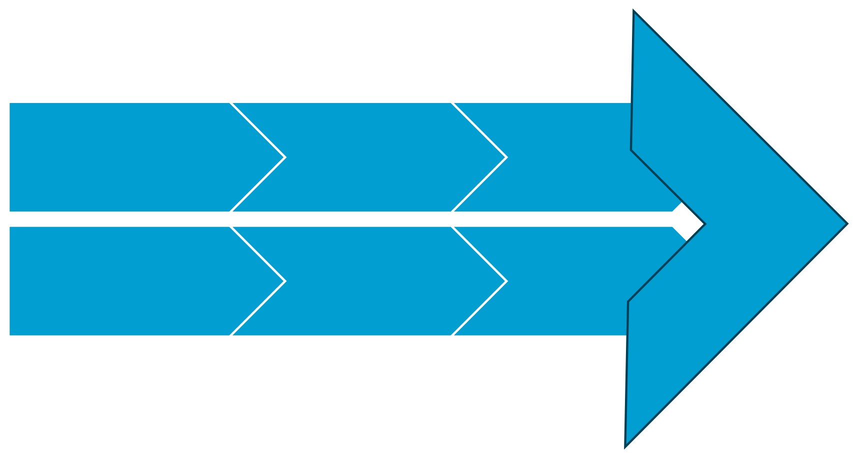
Preliminary End-user Market and Value Chain Review

SS0

Brown AND Caldwell

Why do a Biosolids Market/End-user Study?

- Investigate beneficial reuse options (rather than disposal)
- Plan with the end in mind
  - Will not tell you what product to produce
  - Could tell you what product NOT to produce
- Influence upcoming alternatives and economics of the analyses



Why do a Biosolids Market/End-user Study?

Purpose

- End-user market potential
- Product preferences
- Product value

Additional Insights

- Not all biosolids are created equal – markets dictate the resiliency of a given product
- Greatest vulnerability of a biosolids program is the availability of markets

Market Study Approach

- Exclusions
- Agricultural Market
  - Agricultural Census Data
- Commercial Market
  - Potential Markets
- Market Survey
  - Impressions
  - Takeaways

Exclusions

Organic vs Certified Organic

- National Organic Standards Act prohibited in organic agriculture
  - Illegal to grow food in sewage sludge (aka biosolids) that is sold as certified organic food
  - Cannot certify composts, soils, fertilizers or amendments containing biosolids
  - <1% Farmland Certified Organic

- Organic = Carbon
  - Regenerative practices
  - Sustainable land management

products available OMRI LISTED ™

Agricultural Market

Brown AND Caldwell

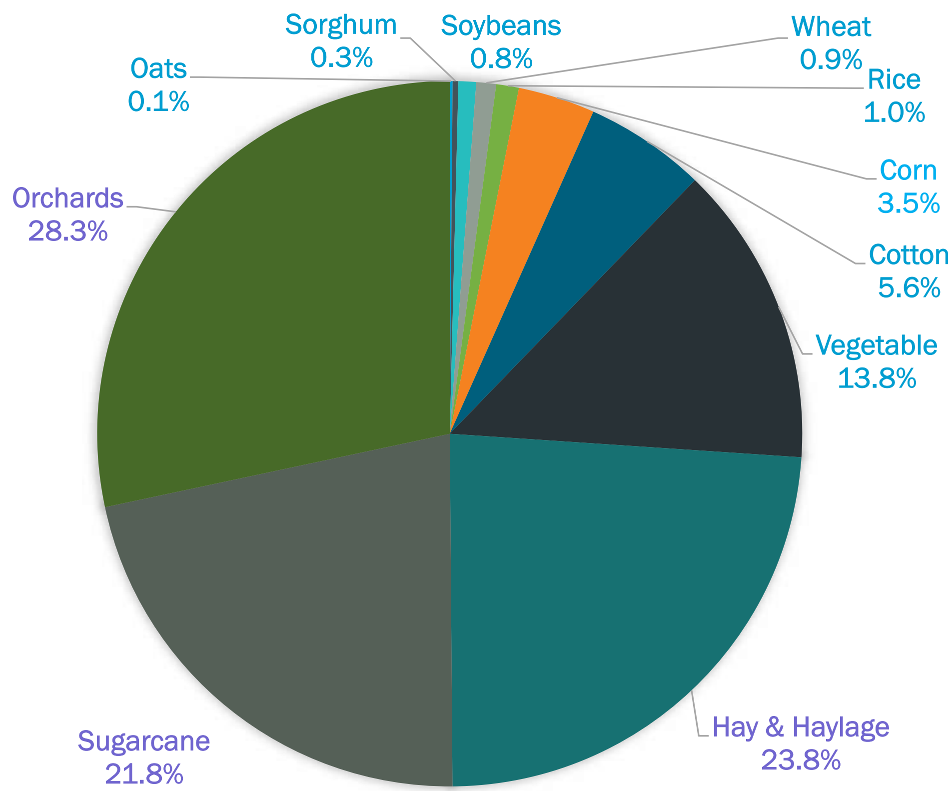
Agricultural Market

- Can absorb majority of biosolids
- Foundation for many successful biosolids end-use programs
- Class AA and Class B
- COMAND®, Synagro, GreenEdge®

Florida Agricultural Survey

	Acres
Farms	9,731,731
Ag land, cropland	2,825,803
Ag land, cropland, harvested	2,093,330
Ag land, irrigated	1,519,379

Major Crops, by acre



Market Takeaways

Agricultural Market

- Considerable land application acreage
- Inexpensive
- Unpredictable legislation
- Landfill disposal is becoming less available
- Competition for land may make land application more expensive

Commercial Market

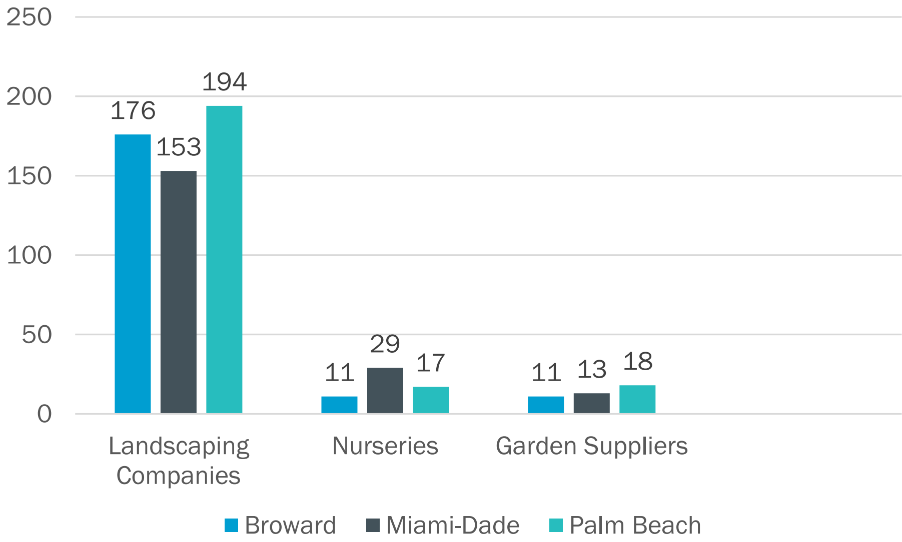
Brown AND Caldwell

Commercial Market

- Increases marketability and end-use options
- Reduces risk from land application restrictions
- Year-round demand
- Biosolids service providers – handoff point for beneficial reuse

- Commercial Businesses
  - Soil blenders
  - Landscape suppliers
  - Landscapers
  - Golf Courses
- Contract Service Providers
  - Composters
  - Biosolids management providers
- Class AA Biosolids

Potential Markets

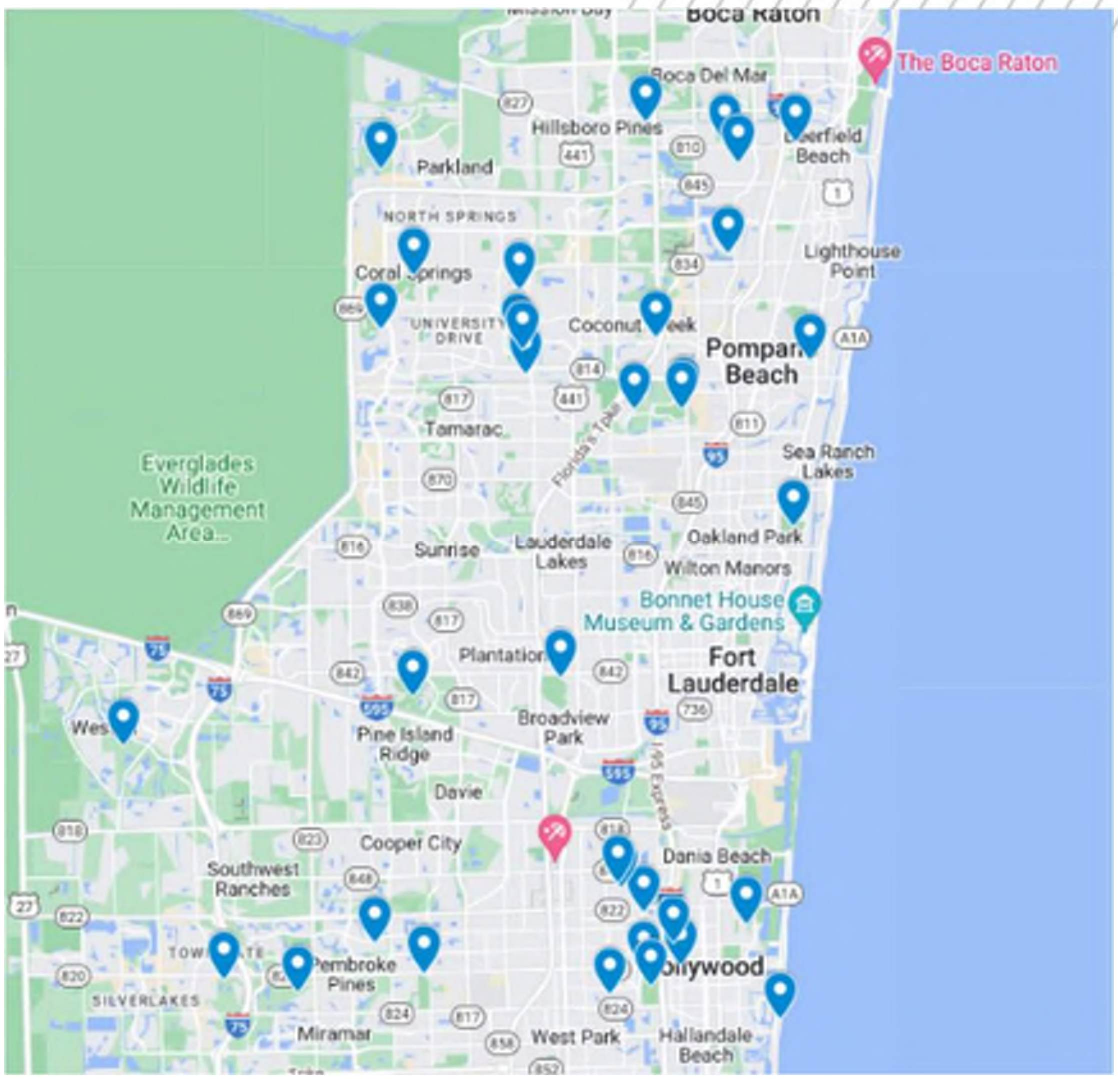


PM0

Potential Markets (continued)

Golf Courses

- 35 golf course in Broward County, FL
- Approx. 11,000 acres of land



Market Survey

- Focused Commercial Market Survey
- Desktop survey conducted through phone interviews
- 33 contacts
  - Soil Blenders
  - Extension Agents
  - Nurseries/ Lawn and Garden Shops
  - Landscapers
  - Golf Courses
  - Service Providers
- Conversation Focus: general impressions of biosolids

Contact Summary & Overall Impressions

Call Success	Number of End Users
Contacted, no response	18
Contacted, declined survey	7
Not interested	0
Completed survey	5
Incomplete survey	2
Total contacts	33

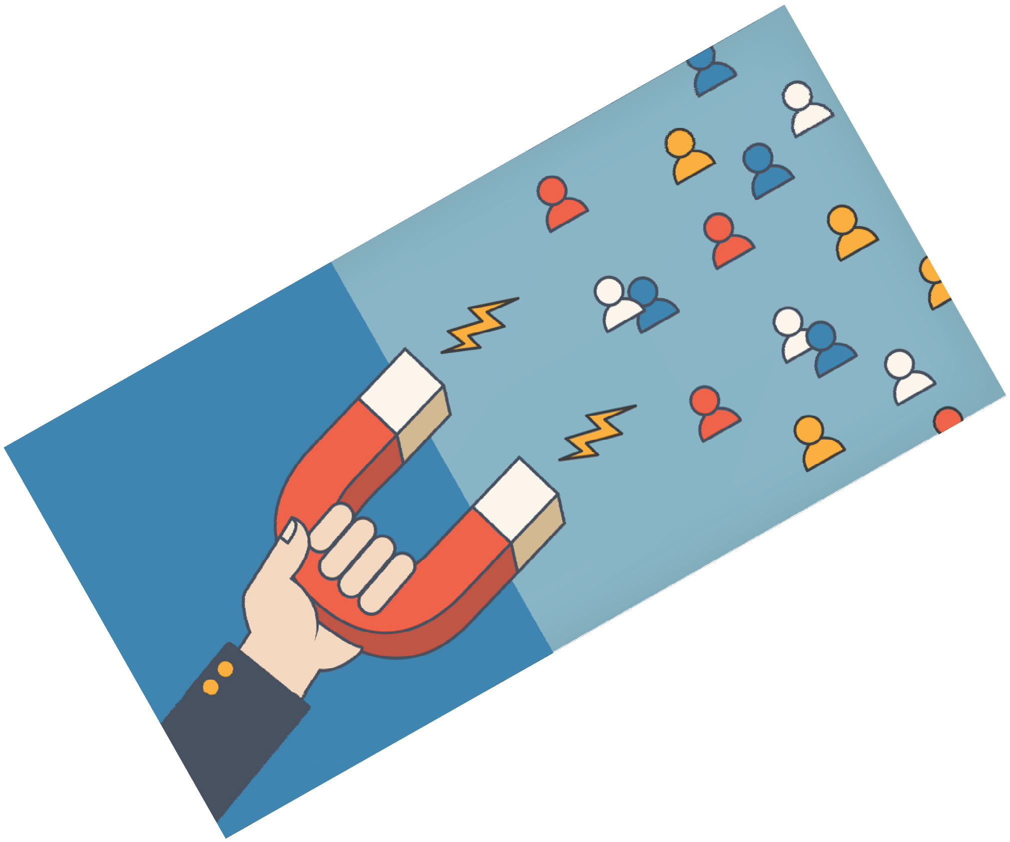
Impressions from Surveyed Contacts	Number of End Users
Positive (+)	2
Mixed (+/-)	3
Negative (-)	0
Not familiar/Not interested	0
Total surveyed contacts	5

Survey

- Nature of the Business
- Seasonal Nature
- Sell/Create Biosolid Products
- Demand for Products
- Price Point

- Soil Blenders
  - They are working on expanding and will carry more organic products at that time.
- Nurseries
  - Sell pelletized biosolid products
  - 0-25% demand for sustainable products
- Landscapers
  - Third parties create their soil mixes

Market Takeaways



Commercial Market

- Winter thru Spring is the busiest time
- Growing interest in the sustainable products
- Sell to landscapers, residential, golf courses

Market Takeaways (continued)

Individual Consumers

- Year-Round Demand
  - Uptick Fall thru Spring
- Stigma, not viewed as an “organic” fertilizer or compost
- Heavy marketing, non-burning soil amendment

Summary/Takeaways

- Agricultural market well established but the future of this market is becoming more unpredictable.
- Commercial market is viable and there is growing interest in sustainable products.
  - Community outreach/education will be required
- Biosolids service providers available for hand-off
  - Handle the marketing

Brown AND Caldwell

Technology Alternatives Analysis

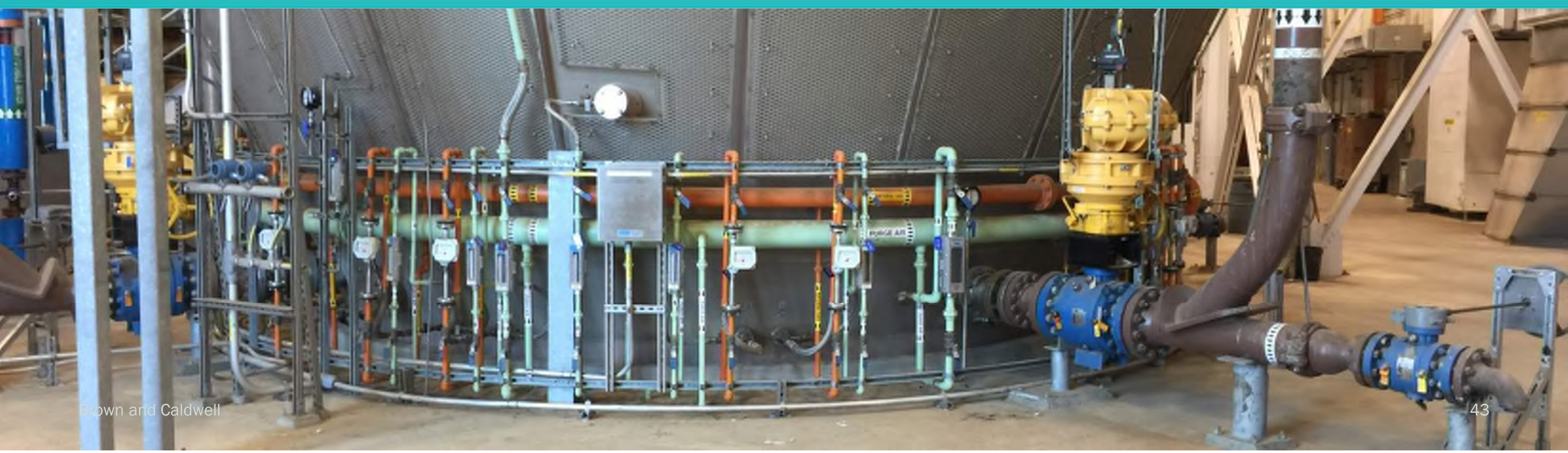
Follow-up from last meeting…

- Feasibility of permitting fluidized bed incinerator
- Feasibility of solar drying for Class A (likely not viable)
- Types of composting

After pass/fail . . .

- THP with Mesophilic Digestion - PASS
- Composting
- Thermal drying - PASS
- ~~Lime stabilization (Schwing Bioset)~~
- ~~Thermal process (Pyrolysis)~~
- ~~Chemical stabilization (Lystek)~~
- Fluidized bed incineration
- Solar Drying

Fluid Bed Incinerators

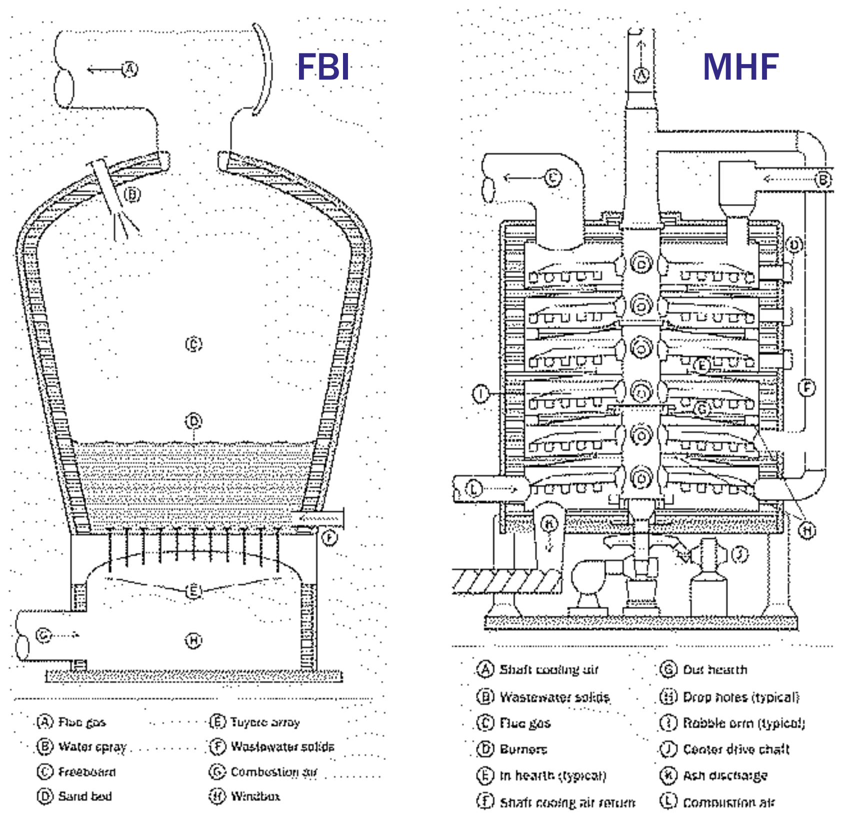


Incineration

- Can incinerators be permitted in Florida?
  - **Yes**
- Talked to David Read – FL Permit Review Administrator
- Incinerators would need to meet federal (most stringent), state, and local regulations
  - Will need to go through public hearing process

Incineration

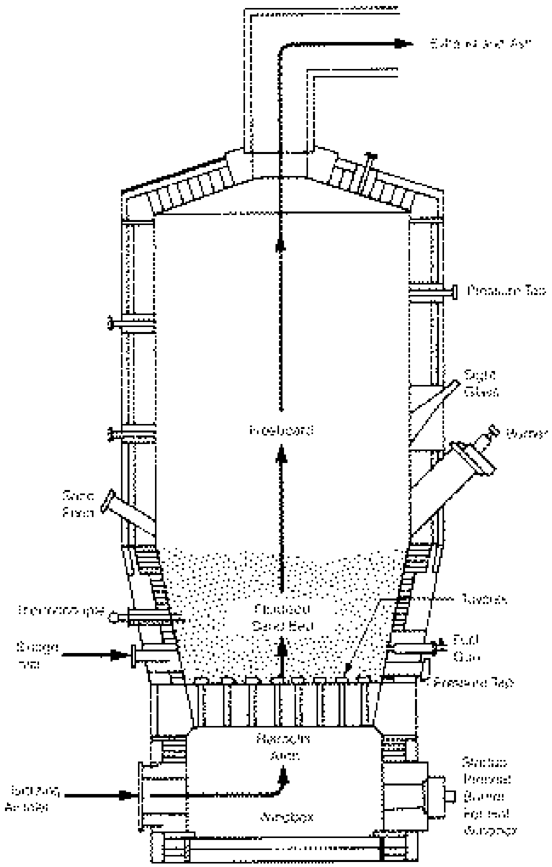
- Incineration (combustion) offers the only thermal process with historical track record
- Fluidized bed and multiple hearth furnaces (FBI/MHF) represent existing installations
- FBI are currently favored from an energy and emissions standpoint



Winchell, L.J., Wells, M.J., Ross, J.J., Fonoll, X., Norton Jr., J.W., Bell, K.Y. PFAS Thermal Destruction at Wastewater Treatment Facilities: A State of the Science Review. *Water Environ. Res.* http://dx.doi.org/10.1002/wer.1483

45

Fluidize Bed Incinerator



Source EPA fact sheet

Pros

- Produces ash
- Volume reduction
- Heat/energy can be recovered
- Small footprint relative to other technologies

Cons

- Public opinion may not be favorable
- Significant/costly emissions controls
- Higher greenhouse gases relative to other technologies

Class-AA Solar Drying

Solar Drying

Can it achieve Class AA on its own?
Maybe (likely with natural gas back-up)

Pros

- Free energy source (sustainable)
- Low installation cost
- Reduced cost (handling, storage)
- Low temperature (less risk of fires and explosions)
- No return stream of condensate
- Volume reduction (Save in hauling charges, if done at the plant)
- Simple operation/low maintenance
- High level of redundancy

Cons

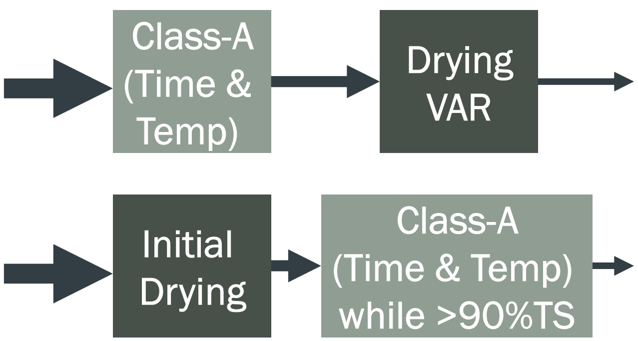
- Product has a high content of pathogens, heavy metals, and organic micropollutants
- Sludge type influences the system
- Area availability
- Dependent on ambient conditions (Humidity/Rain)
- Debris/Hurricanes

Class-A Drying must Meet Time/Temperature and VAR

Two Options for Vector Attraction Reduction:

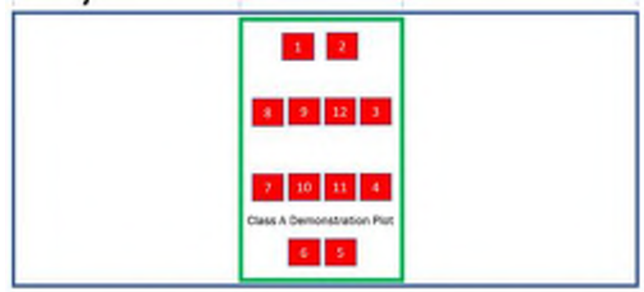
1. If all pre-digested:
   - Needs to be >75% solids
2. If not pre-digested:
   - Needs to be >90% solids

EPA requires that Class-A treatment occurs before or during VAR



Options for Class-A to meet time and temperature:

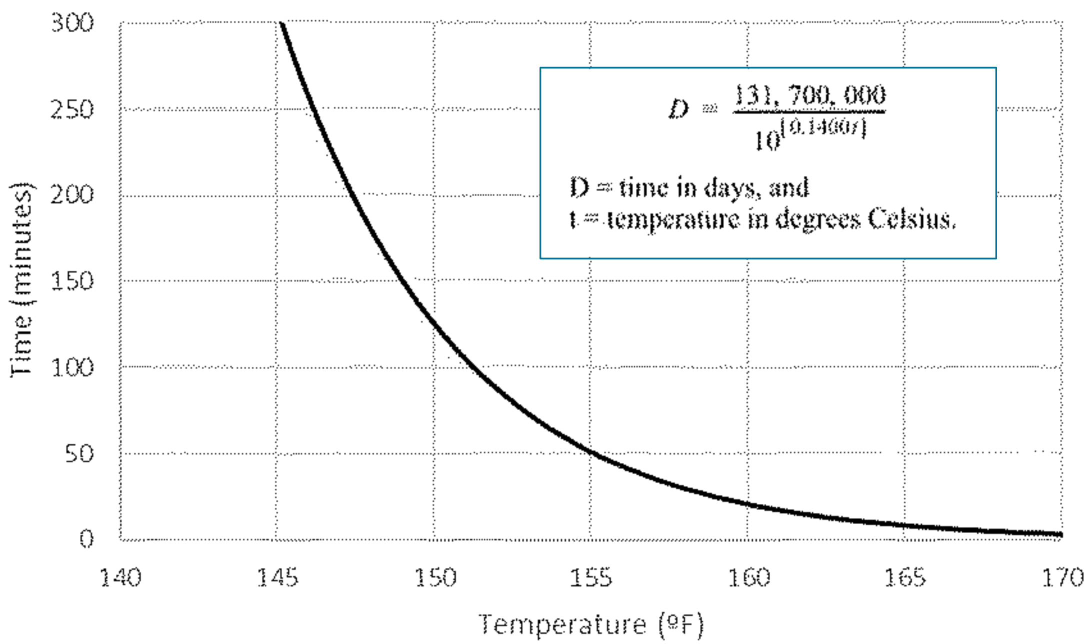
1. Spread/"batched" on a floor:



2. In a pelletizer/conveyor/reactor ensuring time with temperature monitoring

EPA 503 Time/Temperature Requirements

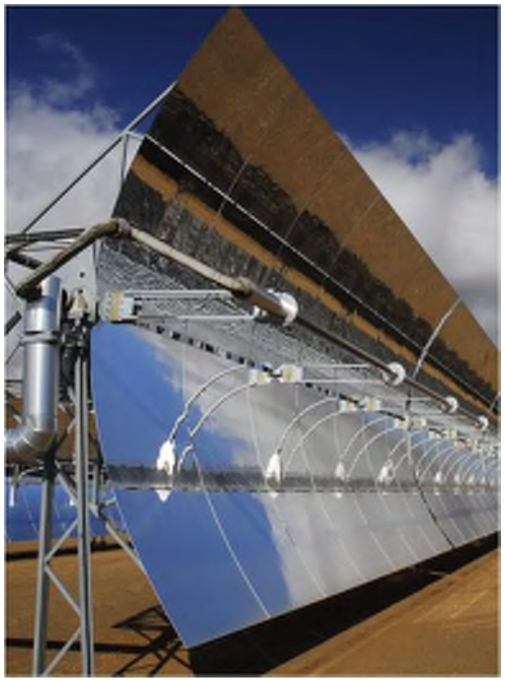
- Minimum hold: 50ºC for 20 minutes (if TS >7%)
- T&T hold defined by equation/curve below
- BC met with EPA Pathogen Equivalency Committee



Data from demonstration-scale supports full scale footprint and design approach

One Potential Full-Scale Embodiment

Full-Scale Demonstration

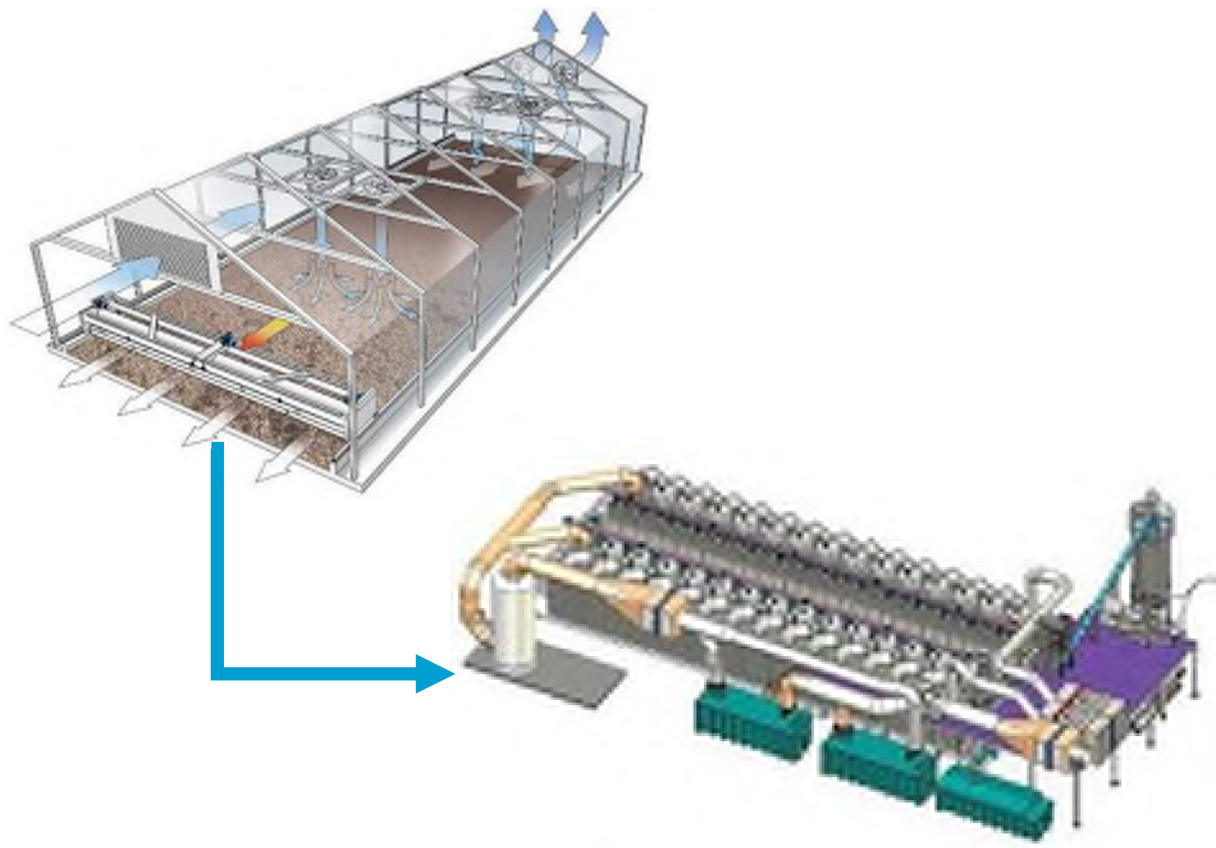


Parabolic Solar Collectors for hot oil

Heated Floor accelerates evaporation

Class AA: Solar Drying with Thermal Dryer/Pelletizer

- Pro
  - Less purchased energy than thermal dryer alone
  - Florida is sunny
- Con
  - Labor intensive
  - Material can be difficult to manage from solar dryer to thermal dryer
  - Expensive relative to thermal dryer or solar dryer alone
  - Florida has high relative humidity



Composting

Composting

– What type of composting can be used in Florida?

- Windrow, Aerated Static Pile, or In-vessel would work in Florida

Aerated Windrow Composting

Arizona Soils Composting Facility - Synagro

- **Elongated pile of stacked raw materials**
- **Requires carbon (brown, 50%), nitrogen (green, 50%)**
- **Oxygen must be replenished as it is consumers**
  - Must be turned (mechanically or manually)

Pros

- Initial Investment is low
- Maintenance is low
- Suitable for large volumes generators

Cons

- Large footprint (addition of bulking agent)
- Time for the process
- Labor Intensive
- Longer time period to produce compost (approx. 6 months)
- Odors and dust could be produced

Passive Aerated Static Pile

Pros
- Initial Investment is low-med
- Maintenance is low-med
- Less Labor Intensive
- Shorter time period to produce compost (45 – 60 days)

Cons
- Large footprint (addition of bulking agent)
- Time to process
- Suitable for large volumes generators
- Odors and dust could be produced

- Perforated pipes within the pile
- Feed stock must be thoroughly pre-mix
- Piles must be insulated with finished compost

Forced Aerated Static Pile

- Blowers are installed at the end of perforated pipes or air ducts
- Air is injected during the active phase (high temp)
- Piles must be insulated with finished compost

Pros
- Less Labor
- Less time to process
- Suitable for large volumes generators
- Shorter time to produce compost (45 – 60 days)

Cons
- Maintenance
- Large footprint relative to other technologies but smaller than Windrow
- High initial investment for blowers
- Odors and dust could be produced, could include a biofilter for odor

In Vessel Composting

Reedy Creek, FL (2010)

- Provides integration and mixing of feed/biology
- Less operator attention

Redundancy for Each Process

Brown AND Caldwell

Basis for Total Solids Loading and System Sizing

	Daily Average at Current				Daily Average at Future Basis of Design (BOD)			
Criterion	Peak-to-Avg.	Dry Tons per Day	%TS	Wet Tons per Day	Factor for Future Cap.	Dry Tons per Day	%TS	Wet Tons per Day
Average Day	1.0	92.1	14.3%	644	1.25	115	13.0%	885
Max-Month	1.15	106	14.3%	741	1.25	132	13.0%	1018
Max-2Wk	1.25	115	14.3%	805	1.25	144	13.0%	1107
Max-Wk	1.35	124	14.3%	870	1.25	155	13.0%	1195
Max-Day	1.5	138	14.3%	967	1.25	173	13.0%	1328

- Population growth 12.5% over 20 years
- Sizing facility to handling 25% growth over 20 years
- Sizing for a minimum of 13% TS to the facility

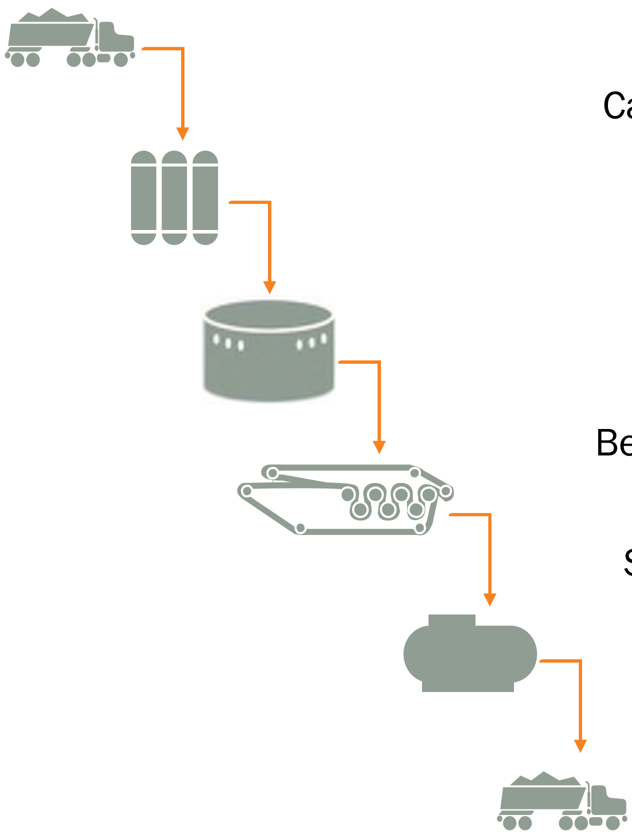
Windrow

- Approximately 40 acres
- Synagro has similar sized facility in Arizona

Aerated Static Pile – Inland Empire Region Facility Example

- This would be twice the size of IEUA
- 22 acres to manage size
- IEUA has 25 full time employees

Redundancy for CAMBI Process



Cake Receiving
- Two truck bays with live bottom hopper.
- Hopper sized to handle difference between peak day and peak week

THP
- Two B6.4 plus one additional flash tank

Mesophilic Digestion
- Sized for 12-day SRT at 9% TS at peak two week leading with one tank out of service

Belt Filter Press
- Sized for max two week loadings with 1 unit out of service

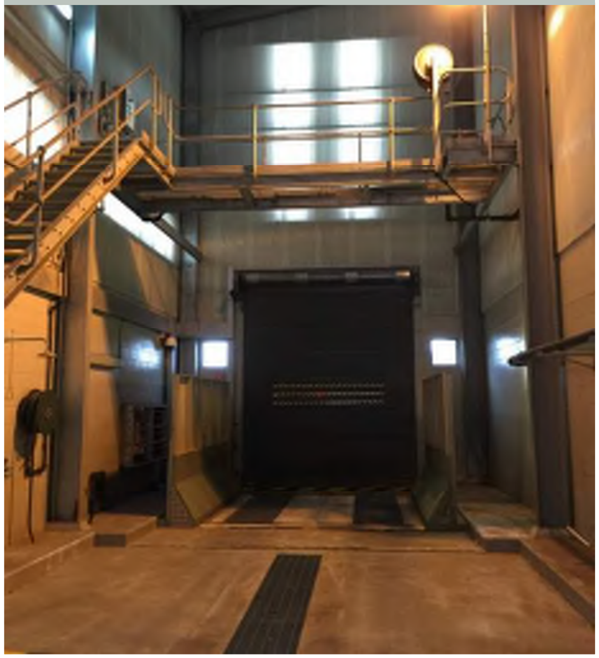
Steam Boilers
- One duty, one standby sized for full CAMBI load
- Will require reuse water system

Hauling
- Two truck bays with live bottom hopper with minimum 12 hours of storage
- Hopper sized to handle difference between peak day and peak week

Redundancy for Trucked Cake Offloading

Enclosed, Drive-through

Oxley Creek, Brisbane



Cake Receiving and Storage would:

- Dampen peak-day loading to peak-week or peak-2wk
- Two bays
- Two live-bottom hoppers w/limited storage
- Storage in two silos

Open, Back-in

Davyhume, Manchester

Redundancy for FBI or Thermal Drying

– Two, ½-Capacity Trains + One Spare

Ash Bridges Bay, Toronto

2x Bays

Piscataway Bioenergy, WSSC, MD

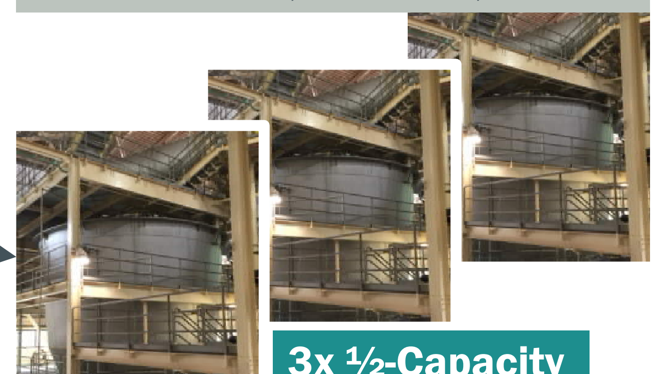
2x ½-Capacity Silos

or

NWWRF, Hillsborough County, FL

3x ½-Capacity Full Drum Dryer Trains

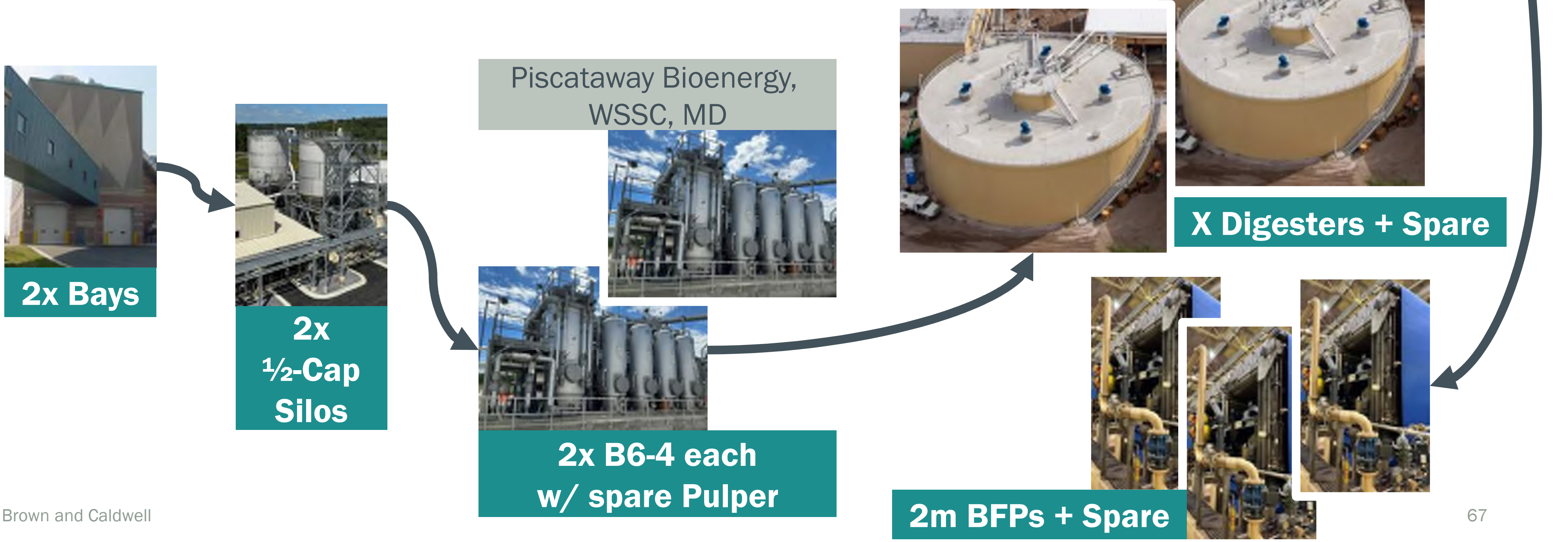
Mill Creek, Cincinnati, OH



3x ½-Capacity Full FBI Trains

Redundancy for CAMBI Process

- Two Cambi B6-4s (each w/ spare pulper)
- Three 1/3-capacity or Two 1/2-capacity Digesters + Spare
- YTBD 2m BFPs + One Spare



Score Technologies

- Excel file

Next Steps

Brown AND Caldwell

Next Steps

– Evaluation of 4 alternatives using SWEET model

Activity	Description	Date
Meeting 4	High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration	November 1, 2023, 2pm to 4pm
Meeting 5	Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost	December 13, 2023, 2pm to 4pm
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 20, 2024
Meeting 7	Phase 3 Recommendations & Report Review (comments due on draft report)	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Thank you.

- Questions?

Brown AND Caldwell

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

November 1, 2023

Agenda

Workshop 4: High Level Alternatives Analysis

- Welcome & Introductions
- Project Overview
- Workshop 4 Content
  - Task 2.1 – Technology Alternatives Analysis
  - Task 2.2 – Alternatives Analysis: Solids Water Energy Evaluation Tool (SWEET) Model
  - Discussion on Hybrid Options
  - Selection of Two (2) Technologies
- Next Steps

Safety Minute - Traveling During the Holidays

- Prepare your home for optimum safety while you are away.
- Make sure your car is in good condition if you're going on a road trip.
- Give someone close to you a copy of your trip itinerary and photocopies of important documents.
- Check the weather before departing and along your route. Plan for travel around any storms that may be coming.
- Check airline requirements.
- Check the requirements to enter your destination.
- Be well rested and alert.

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Project Overview

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are <u>transparent and defendable with consensus</u>

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- <u>Team provides data</u>

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- <u>Team provides input and participates in evaluation</u>

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- <u>Planning document aligned with Team expectations and future vision</u>

Phase 1

Phase 2

Project Schedule

Activity	Description	Date
~~NTP~~	~~Notice to Proceed~~	~~May 4, 2023~~
~~Meeting 1~~	~~Kickoff, Data Request~~	~~May 24, 2023~~
~~Meeting 2~~	~~Data analysis summary, Projection of Future Conditions~~	~~July 26, 2023~~
~~Meeting 3~~	~~Review of Rules and Regulations and Market Assessment~~	~~September 27, 2023, 2pm to 4pm~~
Meeting 4	High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration	November 1, 2023, 2pm to 4pm
Meeting 5	Review of two (2) alternatives, refined SWEET Model	December 13, 2023, 2pm to 4pm
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Workshop Evaluation Approach

1. Review SWEET Model for 4 technologies
2. Sensitivity analysis using SWEET model
   – Utilities asks questions and adjustments made to the model to see effects
3. Utility ranking of 4 alternatives and baseline
4. Discussion and selection of 2 alternatives for further evaluation
   – Further optimized
   – Considerations of hybrid options

Technology Alternatives Analysis

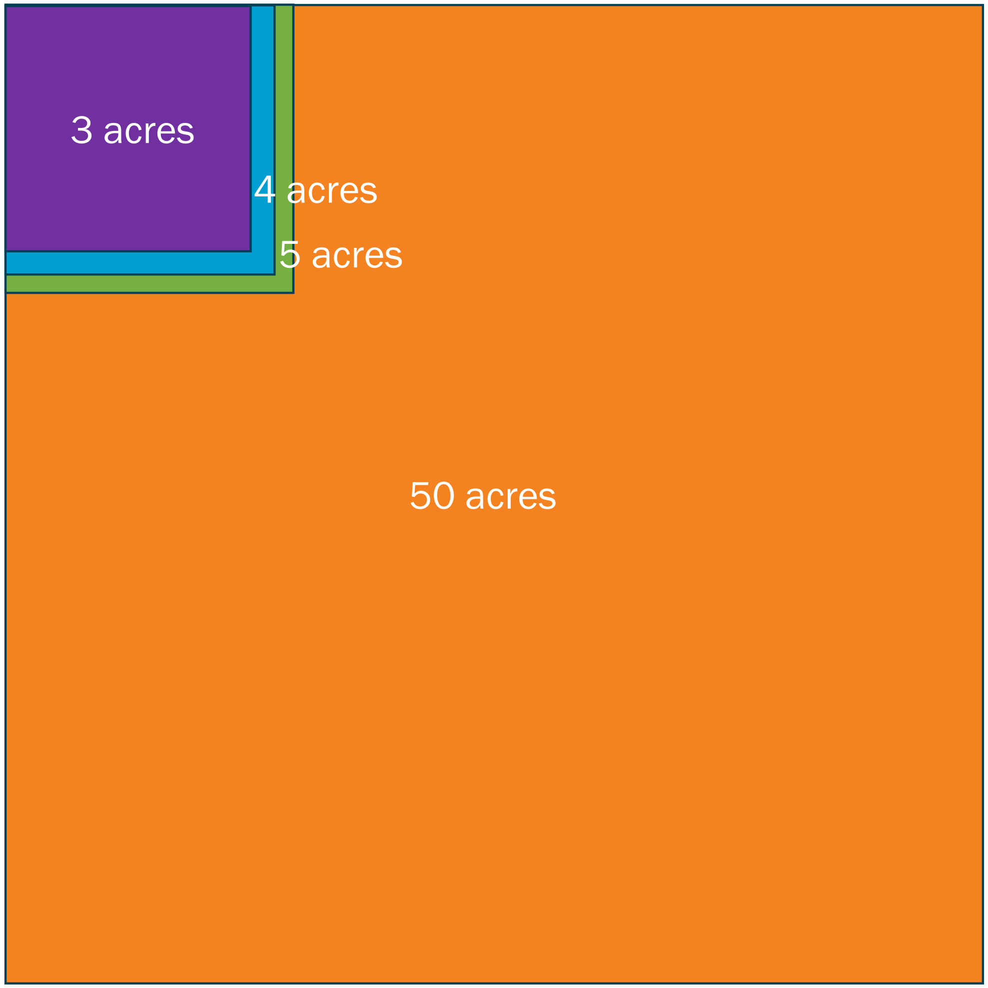
Relative Size by Alternative

Alternative A
THP

Alternative B
Thermal Dryers

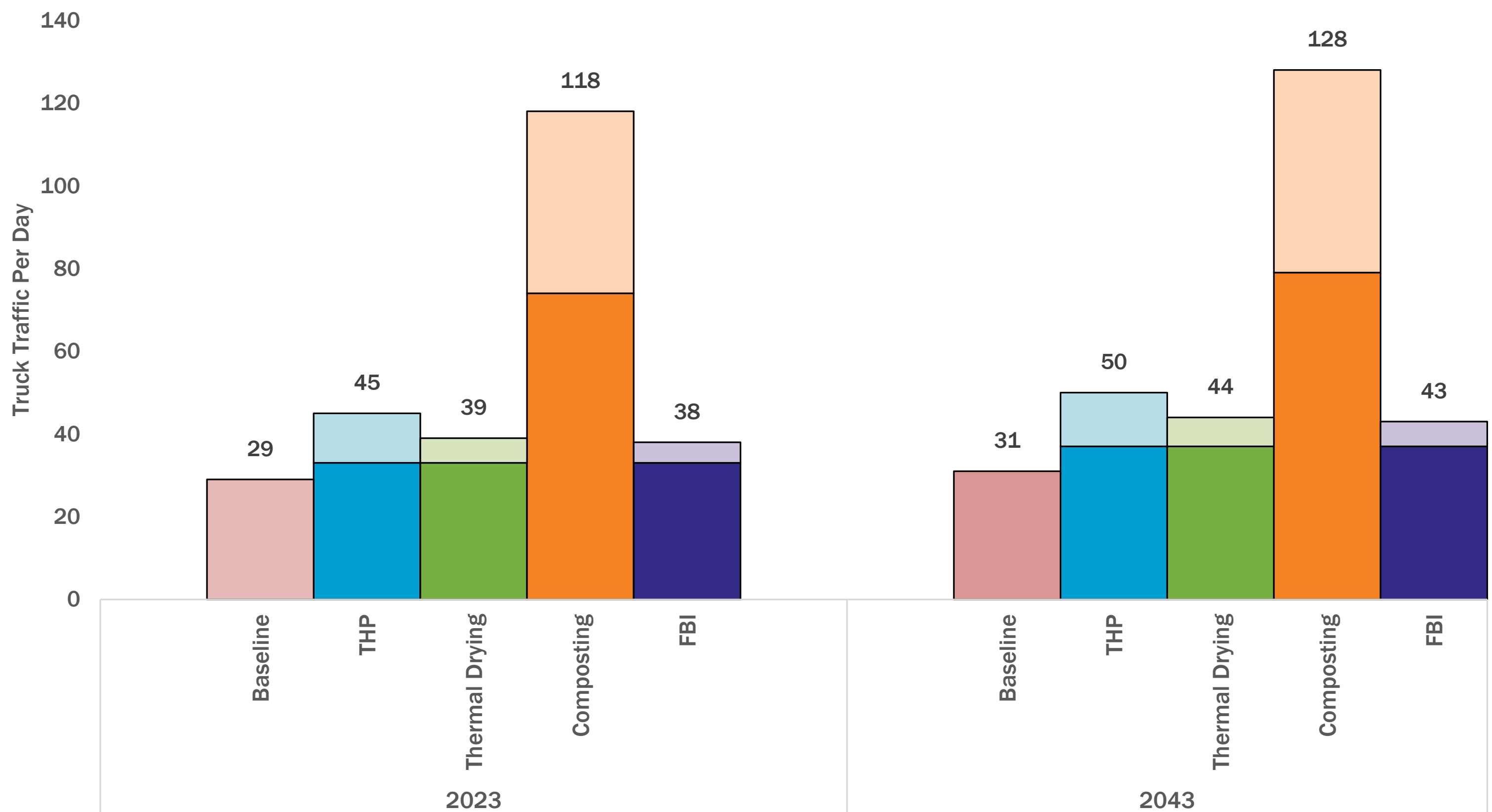
Alternative C
Composting

Alternative D
Fluid Bed Incineration



Truck Traffic

Light color = trucks out
Dark color = truck in



Relative Cost by Alternative

$417M

$674M 20-Yr Present Worth

Alternative A

THP

$567M

$1,034M 20-Yr Present Worth

Alternative B

Thermal Dryers

$372M

$1,086M 20-Yr Present Worth

Alternative C

50-acre Composting Facility

$436M

$783M 20-Yr Present Worth

Alternative D

Fluid Bed Incineration

Cost are not intended to serve as complete construction estimates. These values are comparative and will not be the cost estimate delivered in the bridging documents. Demolition costs for the existing sedimentation basins are not included

Sensitives

Regional Biosolids Solution Study

Sensitivity Analysis using SWEET (Use Solids Water Energy Evaluation Tool) Model

Utility Name: ___________________________________

Units	Parameter	Original	Consider for Sensitivity Analysis (circle)	Suggested new value or range
General				
$/kWh	Electricity (blended rate)	$0.0830	Yes/No	
$/mmbtu	Natural Gas Cost	$13.00	Yes/No	
$/mmbtu	Value of Biogas	$3.00	Yes/No	
$/gal	Diesel Fuel Costs	$3.45	Yes/No	
Biosolids Management				
$/wt	Class-B Baseline Hauling and Tip Fee	$50	Yes/No	
$/wt	Class-AA Cake Land App	$30	Yes/No	
$/wt	Class AA Pellet Sale	$10	Yes/No	
$/wt	Compost Sale	$10	Yes/No	
$/wt	Ash Disposal	$40	Yes/No	
$/wt	Bulking Materials Cost	$10	Yes/No	
$/wt	Hauling to Regional Facility	$10	Yes/No	
mile	Average miles to Pellet Sites	30	Yes/No	
mile	Average miles to Compost Sites	100	Yes/No	

SWEET Live Demo

Alternative Ranking Discussion

Regional Biosolids Solution Study
Technology Rankings and Comments on Evaluation

Utility Name: ______________________________

1. Please rank the following technologies in order of preference.

____ THP ____ Composting

____ Thermal Drying ____ Fluidized Bed Incinerator

2. What, if any, hybrid options should be considered?

____

____

3. What are your drivers for the ranking selected in #1?

Reasons for top ranked technologies:

____

Narrowed Alternatives

Selected Alternative

Selected Alternative

Next Steps

Brown AND Caldwell

Next Steps

Activity	Description	Date
Meeting 5	Review of two (2) alternatives, refined SWEET Model, high level order of magnitude cost	December 13, 2023, 2pm to 4pm
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Thank you.

– Questions?

Brown AND Caldwell

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

December 13, 2023

Agenda

Workshop 5: Review of Alternatives and Refined Model

- Welcome & Introductions
- Project Overview
- Workshop 5 Content
  - Preliminary site assessment
  - Technology review and installation examples
  - Sensitivity analysis using SWEET model
  - Utility ranking of alternatives
  - Selection of top alternative
- Next Steps

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Project Overview

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are transparent and defendable with consensus

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- Planning document aligned with Team expectations and future vision

Phase 1

Phase 2

Project Schedule

Activity	Description	Date
~~NTP~~	~~Notice to Proceed~~	~~May 4, 2023~~
~~Meeting 1~~	~~Kickoff, Data Request~~	~~May 24, 2023~~
~~Meeting 2~~	~~Data analysis summary, Projection of Future Conditions~~	~~July 26, 2023~~
~~Meeting 3~~	~~Review of Rules and Regulations and Market Assessment~~	~~September 27, 2023, 2pm to 4pm~~
~~Meeting 4~~	~~High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration~~	~~November 1, 2023, 2pm to 4pm~~
Meeting 5	Review of two (2) alternatives, refined SWEET Model	December 13, 2023, 2pm to 4pm
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Site Assessment

Relative Size by Alternative

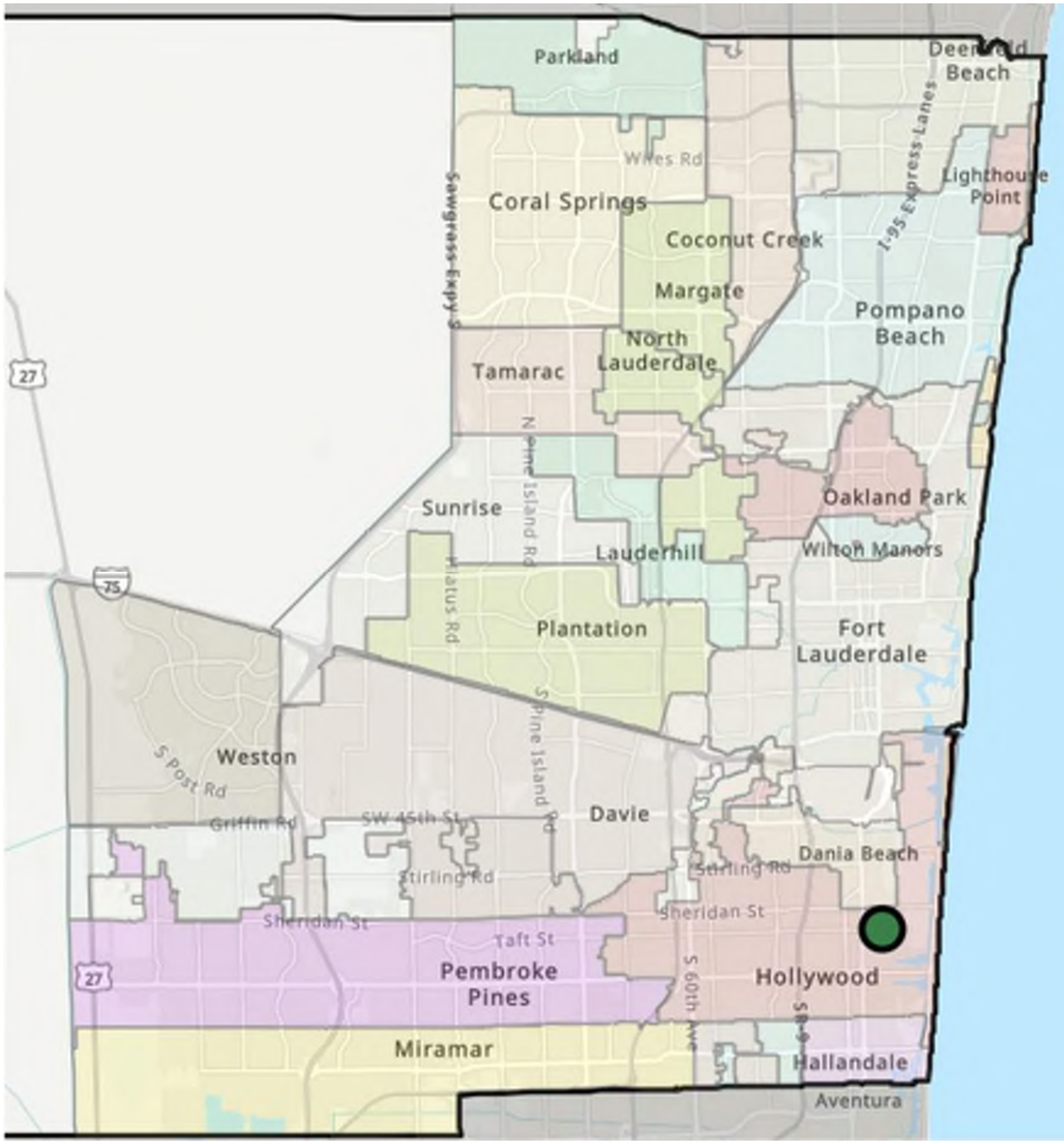
Alternative A
THP

Alternative B1
Thermal Dryers

Alternative B2
Hybrid (Thermal Dryers w/Solar)

Site Assessment

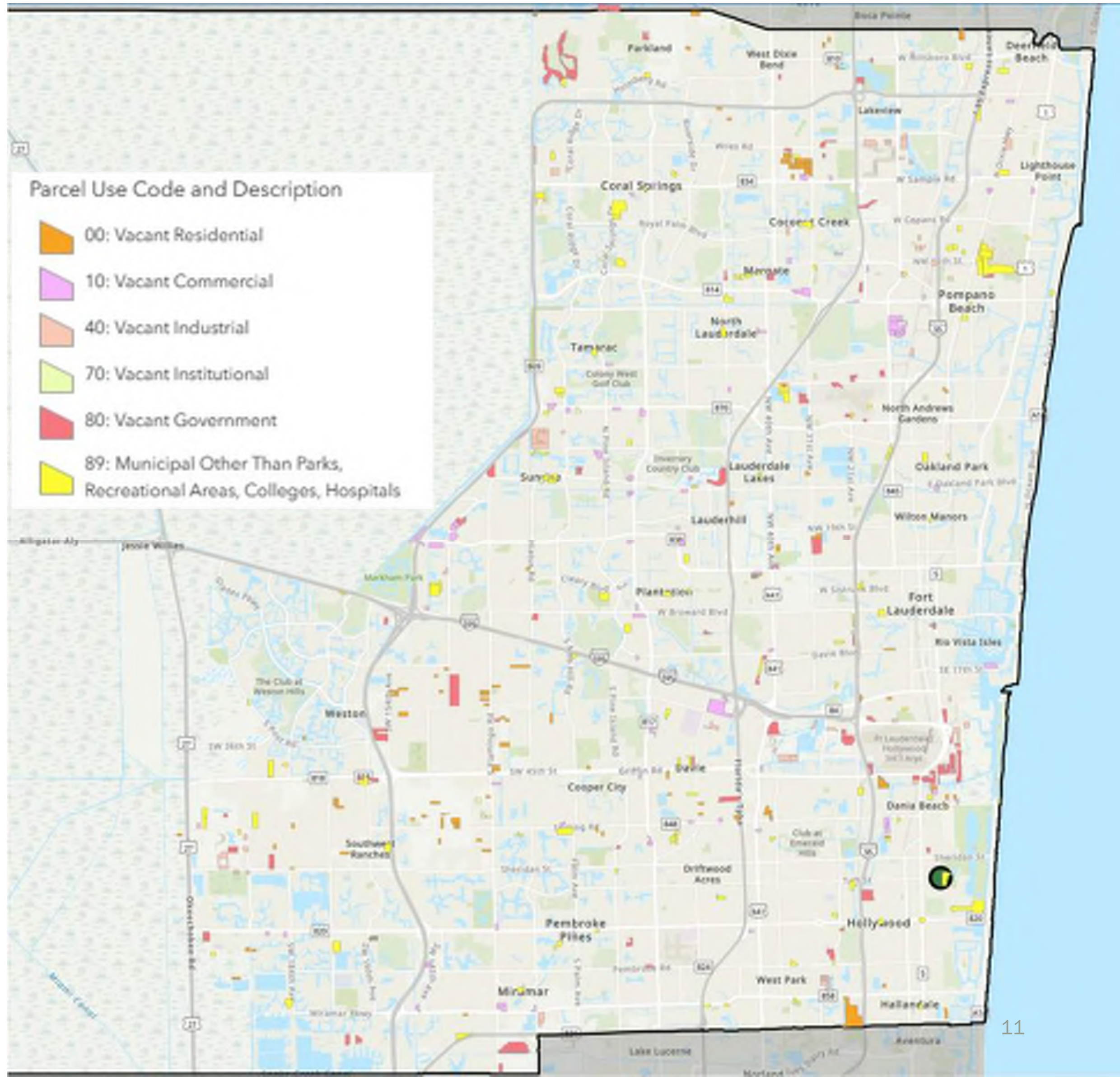
- Criteria:
  - (>=) 4, 5, and 10 acres
  - Vacant Properties
  - Owned by:
    - Residential
    - Commercial
    - Industrial
    - Institutional
    - Government
    - Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals



Site Assessment – Alternative (4 Ac)

– Number of available sites by owner type:

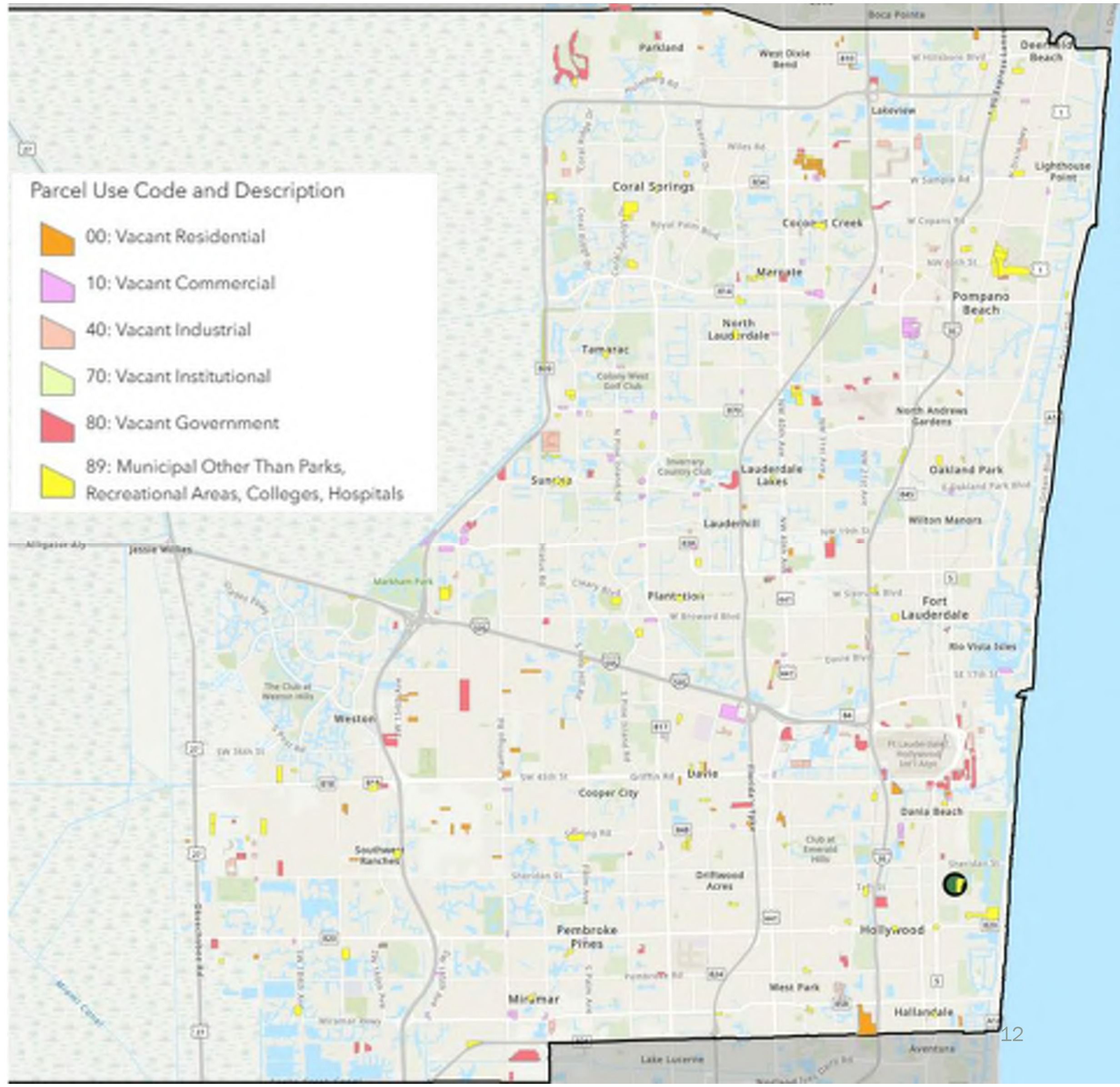
- TOTAL (794)
- Vacant Residential (393)
- Vacant Commercial (89)
- Vacant Industrial (52)
- Vacant Institutional (13)
- Vacant Government (119)
- Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals (128)



Site Assessment – Alternative (5 ac)

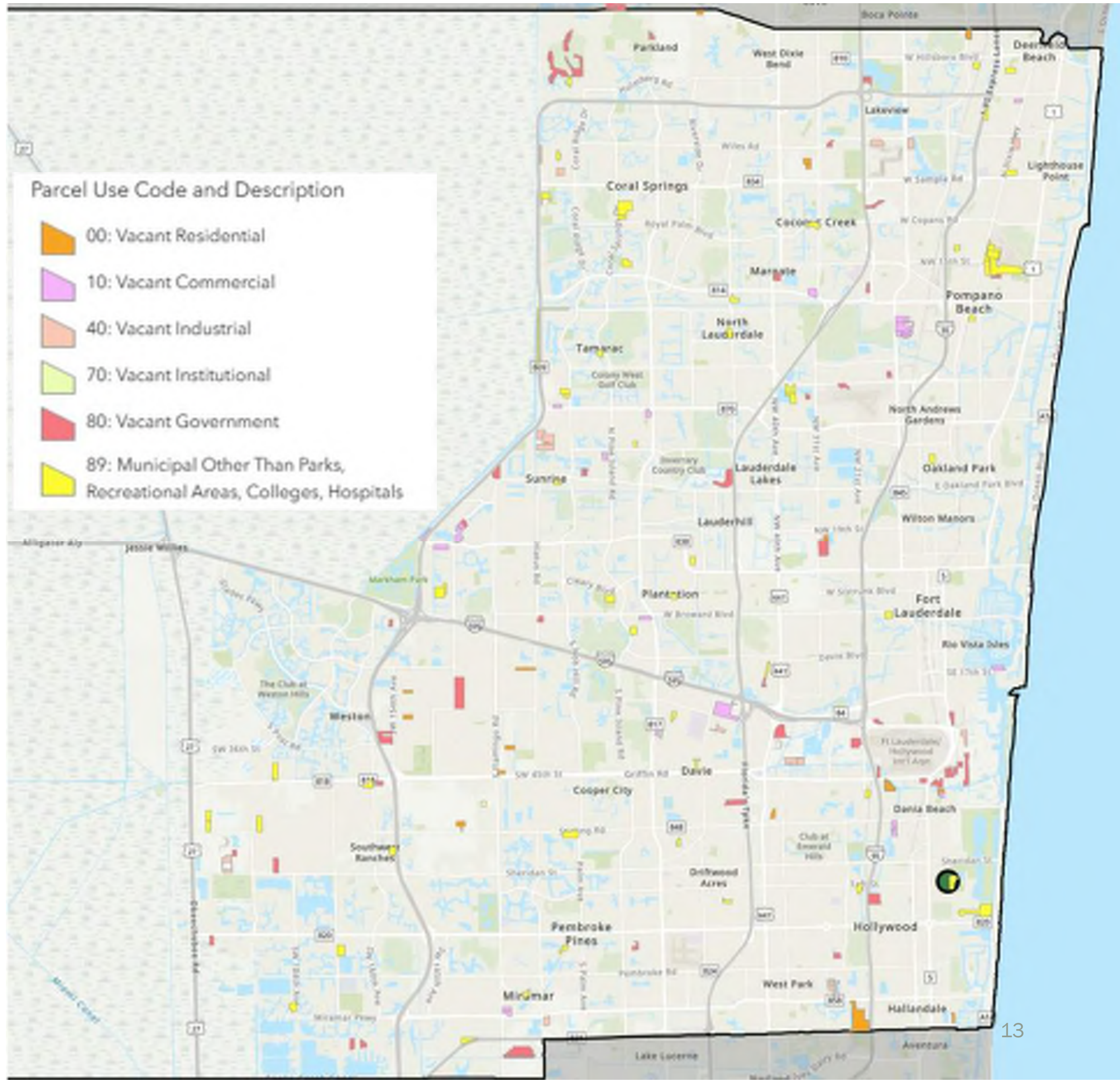
– Number of available sites by owner type:

- TOTAL (617)
- Vacant Residential (283)
- Vacant Commercial (63)
- Vacant Industrial (40)
- Vacant Institutional (10)
- Vacant Government (107)
- Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals (114)



Site Assessment – Alternative (10 ac)

- Number of available sites by owner type:
  - TOTAL (376)
  - Vacant Residential (212)
  - Vacant Commercial (24)
  - Vacant Industrial (15)
  - Vacant Institutional (1)
  - Vacant Government (63)
  - Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals (61)



Technology Alternatives Analysis

Brown AND Caldwell

Workshop 4 – Comments on Evaluation Summary

- THP – top ranked
  - Cost
  - Land, compact size
  - Lower capital investment, lower chemical cost, lower maintenance cost
  - Efficiency
  - Impact on environment
  - Annual operating cost
  - Cost effective volume reduction (lower haul sizes & cost)
- Thermal Drying – top ranked
  - Proven technology, reliable

Relative Cost by Alternative

$407M

$675M 20-Yr Present Worth

Alternative A

THP

$466M

$687M 20-Yr Present Worth

Alternative A2

THP + RNG

$581M

$998M 20-Yr Present Worth

Alternative B1

Thermal Dryers

$598M

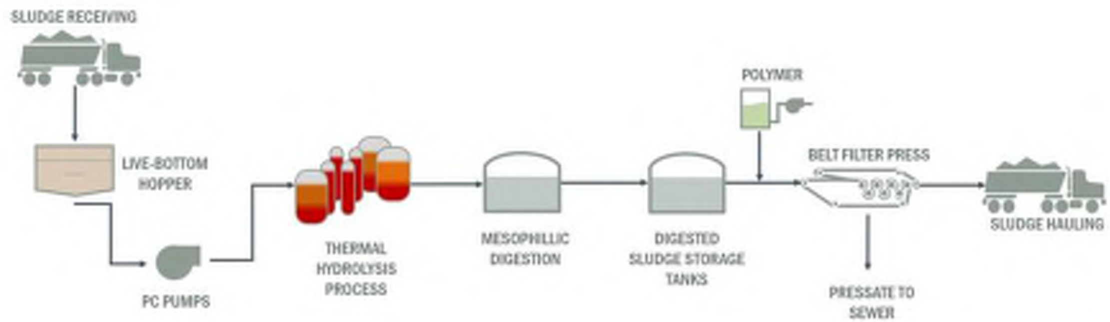
$928M 20-Yr Present Worth

Alternative B2

Thermal Dryers w/Solar

Cost are not intended to serve as complete construction estimates. Land costs not included

Alternative A:
Thermal Hydrolysis



Capital Elements

- Sludge receiving station with live bottom hoppers
- Sludge storage tanks (2-day storage)
- Four THP B6.4 units (CAMBI)
- Two - 3 MG mesophilic digesters
- Digested sludge storage tank
- Belt filter press dewatering units
- Filtrate sump pumps
- Steam boiler

Alternative A: Thermal Hydrolysis

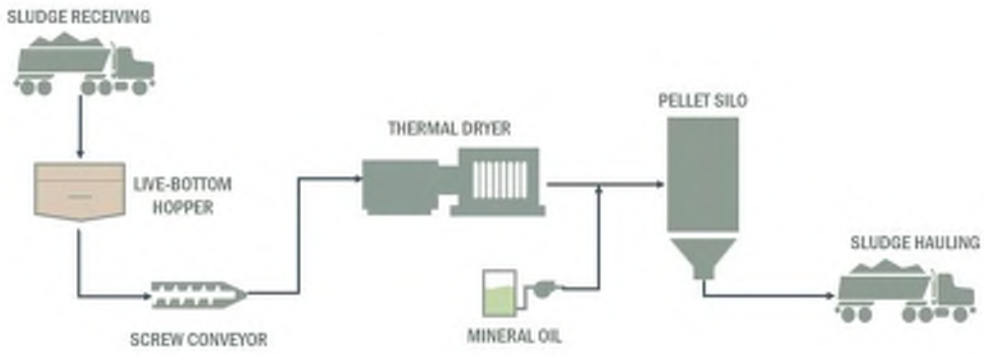
- Pros:
  - Low to no natural gas demand
  - Class A product
  - Better solids destruction and dewatering reduces wet mass
  - Produces biogas
- Cons:
  - Increased process complexity
  - Boiler code operator needed
  - Side stream requires treatment

THP (Cambi) – Installations and Experiences

- ~7 in operation, ~6 under construction
- DC Water (Washington DC)
  - 1200 wet tons per day
  - 450 dry tons per day
  - 16-17% solids
  - Year online: 2014
- Trinity River Authority (Dallas, TX)
  - 120 dry tons per day
  - 15-18% solids
  - Year online: 2023

<u>Regional Facility In Planning</u>
610 wet tons per day
108 dry tons per day
~13.5% solids

Alternative B1: Thermal Drying



Capital Elements

- Sludge receiving station with live bottom hoppers
- Sludge conveyance
- Four – DDS110 Thermal Dryers
- Four RTOs for odor control
- Five pellet silos

Alternative B: Thermal Drying

Pros:

- Well known technology for biosolids management
- Creates low volume of marketable pellets

Cons:

High capital costs for thermal drying

Low feed solids impacts sizing and operation

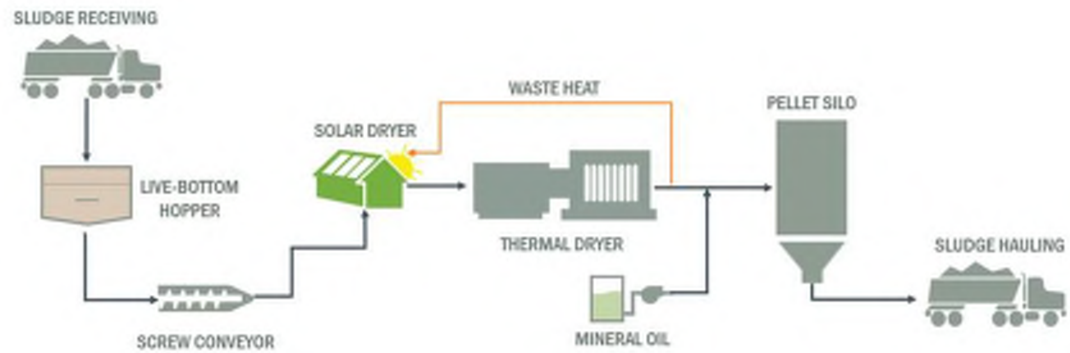
High natural gas demand

Thermal Dryer – Installations and Experiences

- Hundreds in operation since at least the 1950s
- Palm Beach County SWA
  - 600 wet tons/day
  - About 12-18% solids but participating utilities are allocated a %TS
  - Uses landfill gas
  - Year online: 2009

<u>Regional Facility In Planning</u>
610 wet tons per day
108 dry tons per day
~13.5% solids

Alternative B2:
Hybrid (Thermal Drying w/ Solar)



Capital Elements

- Ten solar green houses
- Four DDS 110 Thermal Dryers
- Uses recovered waste heat from the dryers to heat solar dryers
- Greenhouses on 5 additional acres
- Goal: 20-26% solids to remove a dryer

Alternative B2:
Hybrid (Thermal Drying w/ Solar)

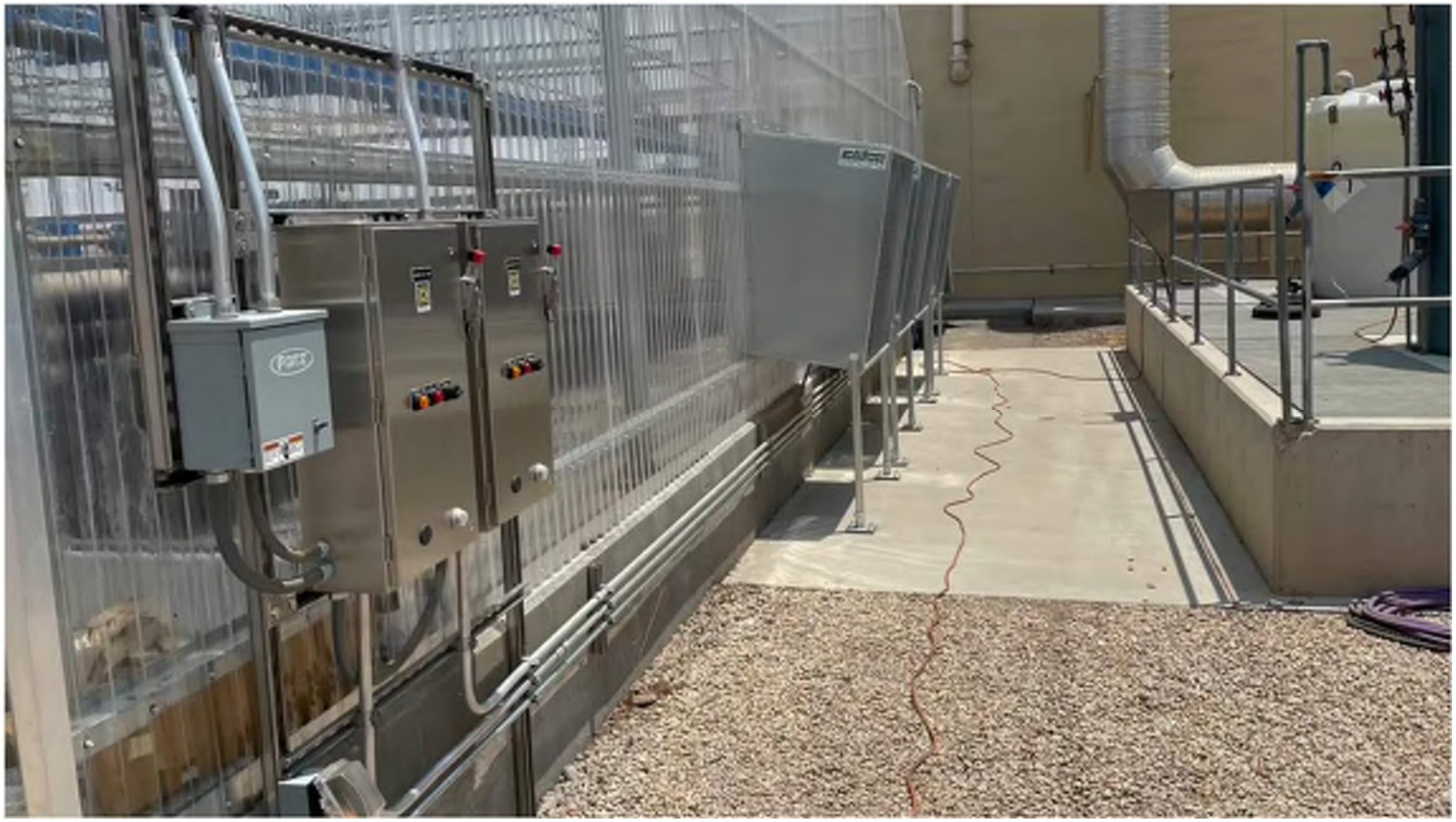
- Pros:
  - Well known technology for biosolids management
  - Creates low volume of marketable pellets
  - Reduce number of thermal dryers needed
  - Reduces the amount of natural gas required by over 50%
  - Solar technology is simple and well known
- Cons:
  - Relatively high capital costs for thermal drying
  - Increased land use and acquisition for solar operation
  - Increased land use (5 additional acres)
  - Complex mechanical system for thermal dryers

Solar Dryer – Installations and Experiences

- FloridaGreen (Pasco County, FL)
  - Solar drying and oven pasteurization system developed by Merrell Bros, Inc.
  - Processes about 50,000 wet tons per year

Solar Dryer Examples

Solar Dryers in Surprise, Arizona



Sedron with Varcor Dryer

- Proposed Sedron facility in Indiantown, FL
- Proposed Capital: $60M
- Proposed Tip Fee: $65/wt
- Estimated Hauling Fee: $45/wt
- 20-year Present worth: $792M
  - Present worth capital at $180M

Basis of BC Cost Estimates

- Redundancy/level of service
- Planning fallacy
- Very little detail behind estimates

- Next step would be to preliminary design solution(s) and develop class 5 estimate

SWEET Sensitivity Analysis

Brown AND Caldwell

Selection of Technology

Brown AND Caldwell

Technology Ranking Sheets

- One sheet per municipality
- Break out for discussions to determine top ranked technology and justifications

Next Steps

Next Steps

Activity	Description	Date
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Thank you.

– Questions?

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

February 7, 2024

Agenda

Workshop 6: Site Assessment and Delivery Models

- Welcome & Introductions
- Project Overview
- Selected Alternative Overview
- Workshop 6 Content
    - Site Assessment
    - Delivery Models & Governance
- Next Steps

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Project Overview

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- This group came together to explore regional solutions
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are transparent and defendable with consensus

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis

- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model

- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps

- Planning document aligned with Team expectations and future vision

Phase 1 — Phase 2

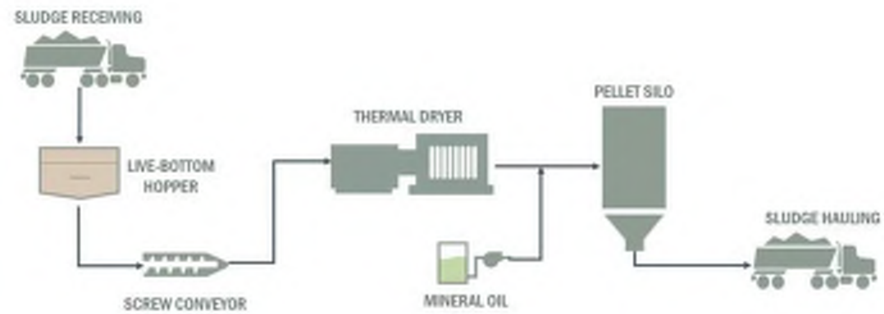
Project Schedule

Activity	Description	Date
~~NTP~~	~~Notice to Proceed~~	~~May 4, 2023~~
~~Meeting 1~~	~~Kickoff, Data Request~~	~~May 24, 2023~~
~~Meeting 2~~	~~Data analysis summary, Projection of Future Conditions~~	~~July 26, 2023~~
~~Meeting 3~~	~~Review of Rules and Regulations and Market Assessment~~	~~September 27, 2023, 2pm to 4pm~~
~~Meeting 4~~	~~High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration~~	~~November 1, 2023, 2pm to 4pm~~
~~Meeting 5~~	~~Review of two (2) alternatives, refined SWEET Model~~	~~December 13, 2023, 2pm to 4pm~~
Meeting 6	Site assessment and delivery models	February 7, 2024, 2pm to 4pm
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Selected Alternative

Brown AND Caldwell

Selected Alternative: Thermal Drying



Capital Elements

- Sludge receiving station with live bottom hoppers
- Sludge conveyance
- Four – DDS110 Thermal Dryers
- Four RTOs for odor control
- Five pellet silos

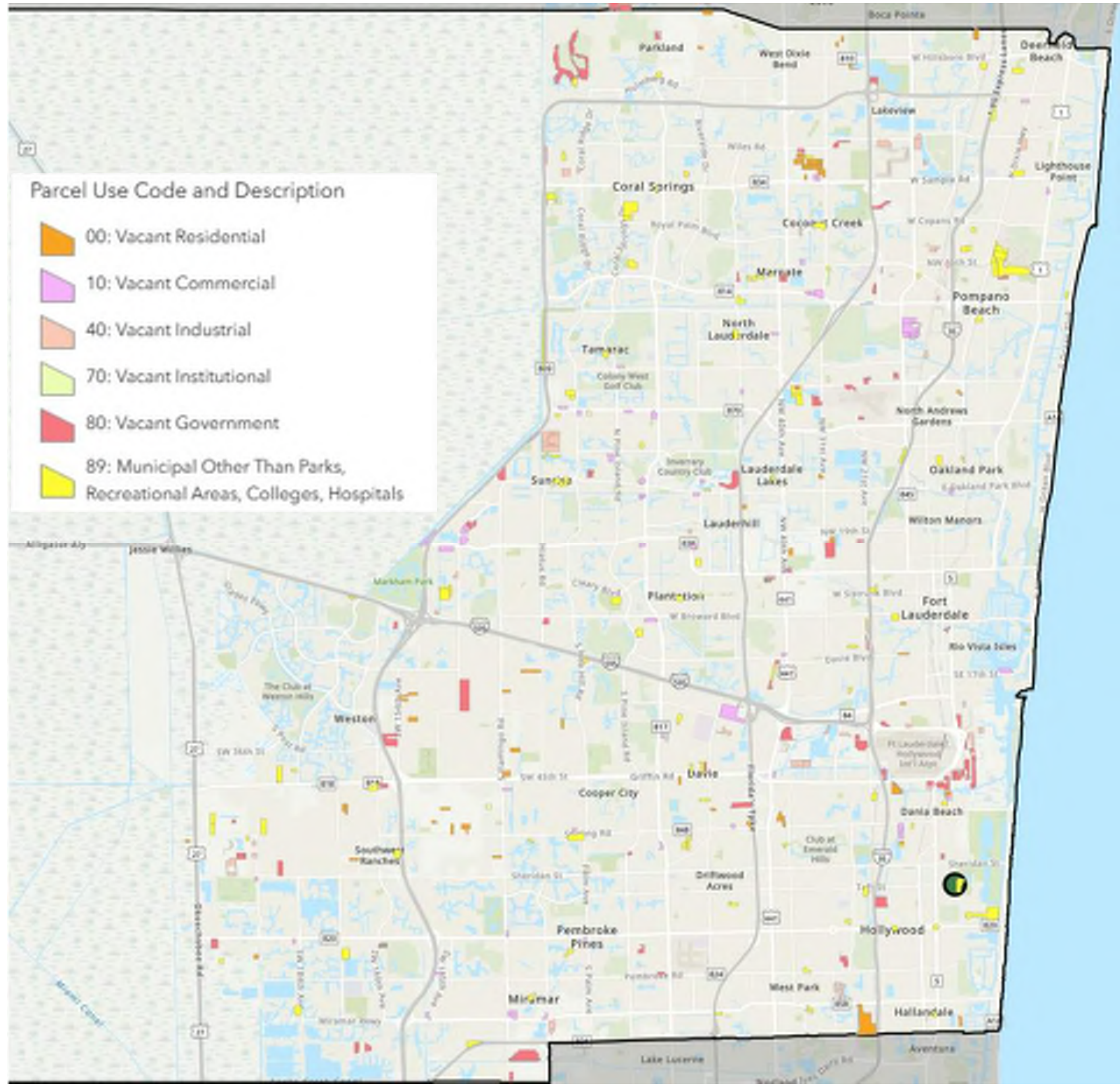
Site Assessment

Brown AND Caldwell

Site Assessment – Alternative (5 ac)

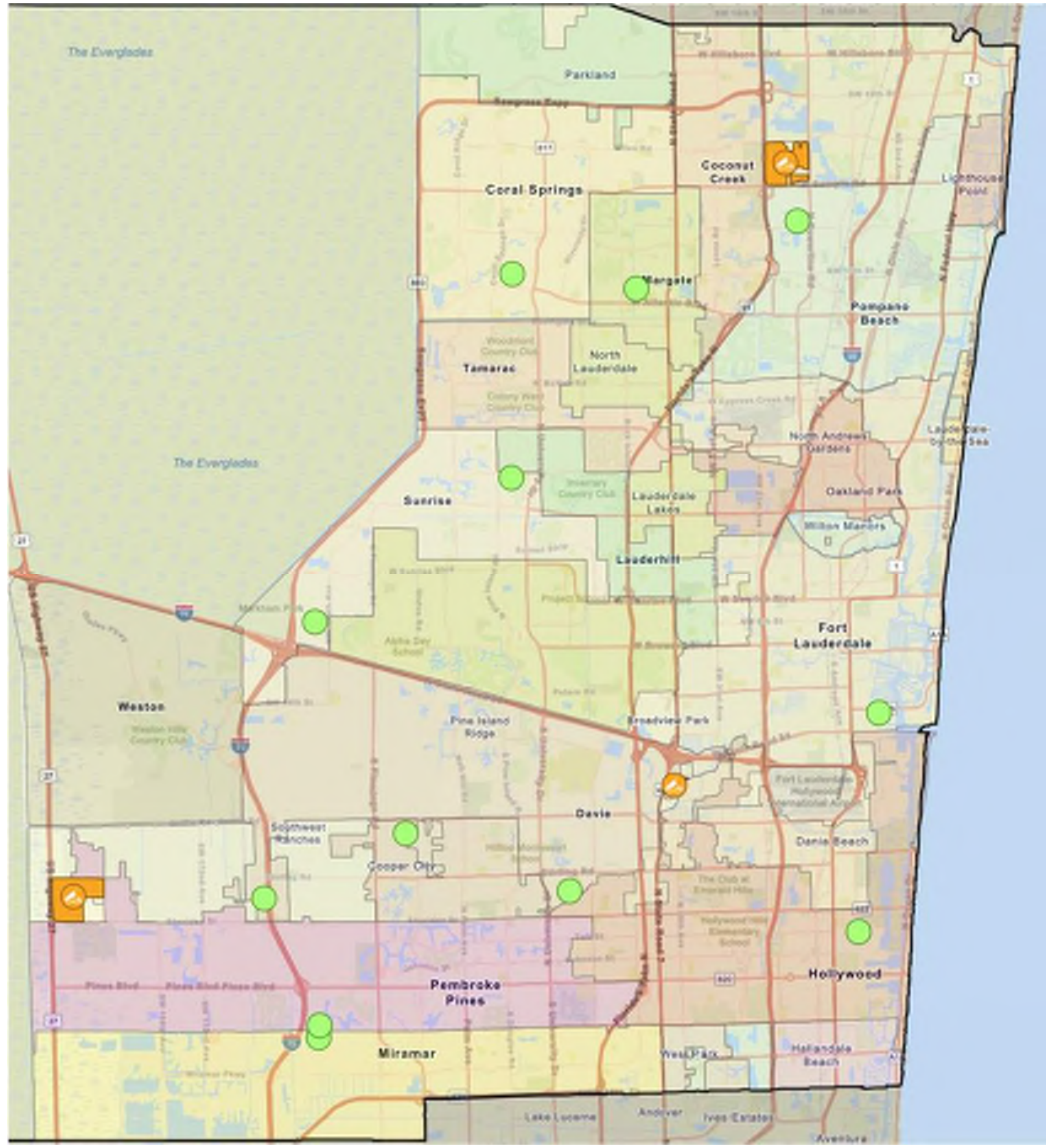
Number of available sites by owner type:

- **TOTAL (617)**
- Vacant Residential (283)
- Vacant Commercial (63)
- Vacant Industrial (40)
- Vacant Institutional (10)
- Vacant Government (107)
- Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals (114)



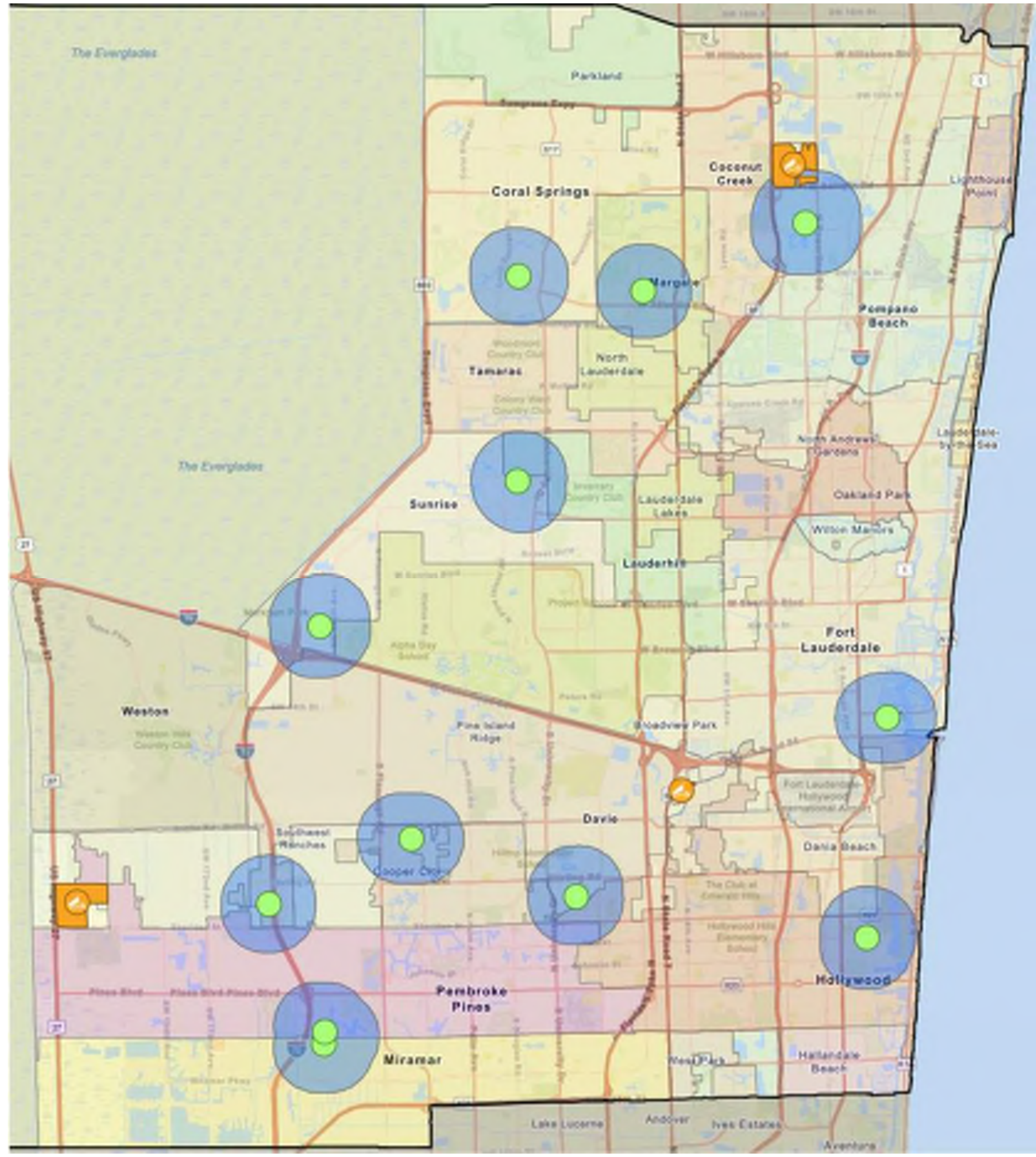
Location of WWTP and Landfills in Broward County

- 12 Wastewater Treatment Plants within Broward County (BC)
- 3 Landfills within BC



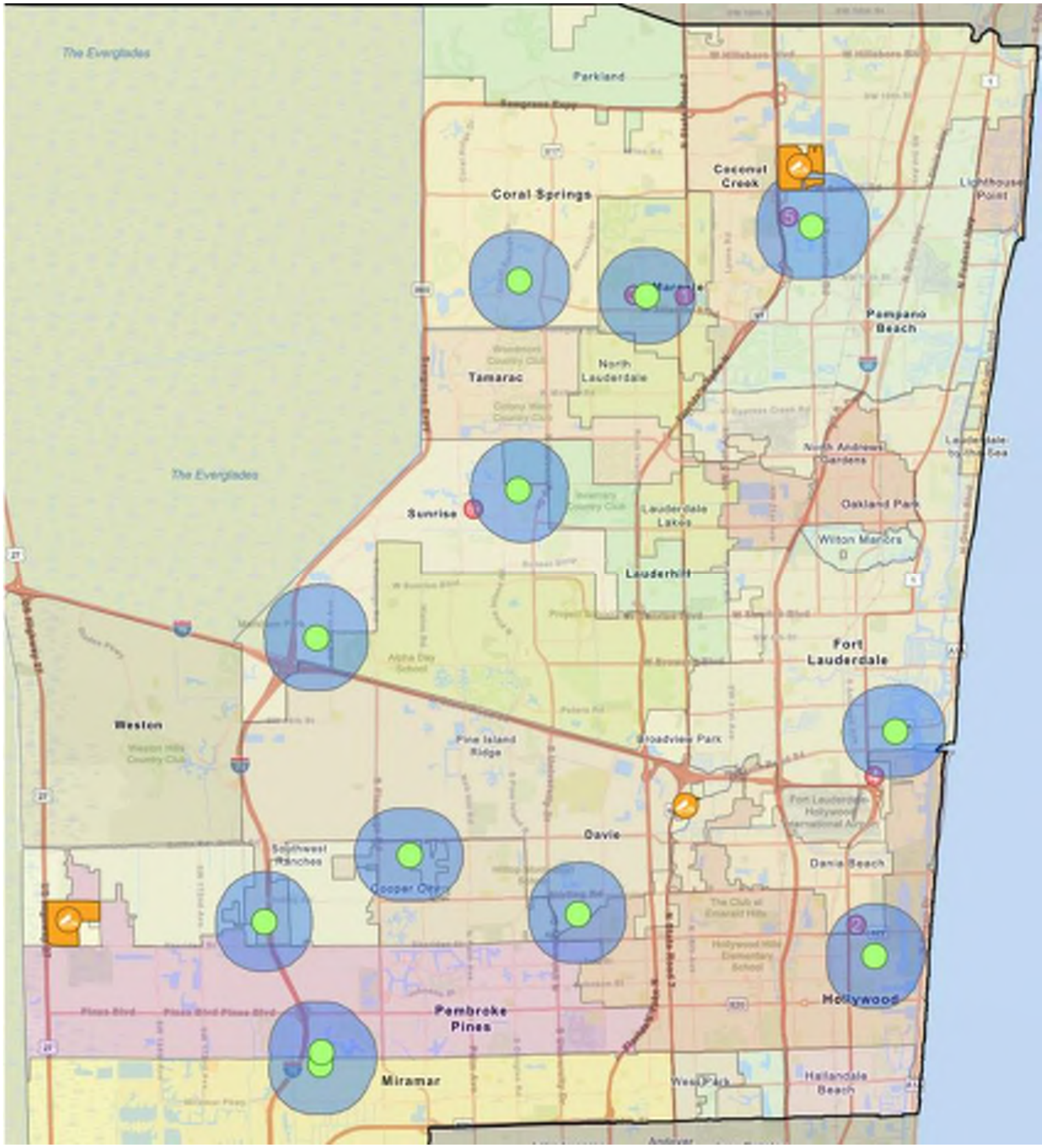
Site Criteria

- Site Criteria:
  - Proximity to WWTP (within 1 mile)
  - Proximity to Landfills
  - >5 acres
  - Vacant Properties
  - Access to Reclaimed Water
  - Access to Natural Gas
  - Ownership preference:
    1) Government
    2) Municipal Other Than Parks, Recreational Areas, Colleges, Hospitals
    3) Privately Owned (all others)



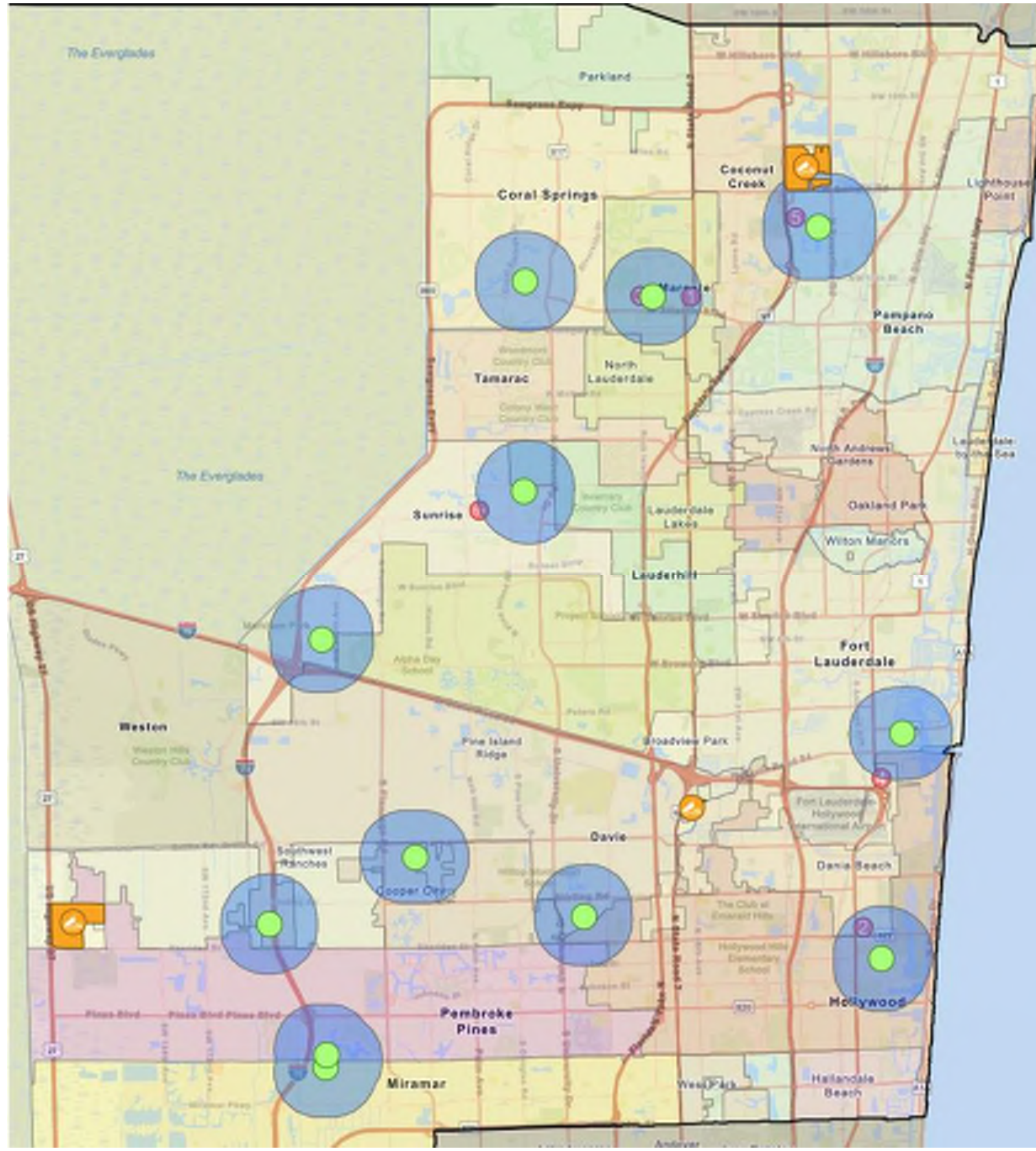
Vacant Properties within 1 mile from WWTP

- Sites Meeting New Criteria:
  - TOTAL (61)
  - Vacant Government Owned: 16
  - Municipal Other: 18
  - Privately Owned (all others): 27

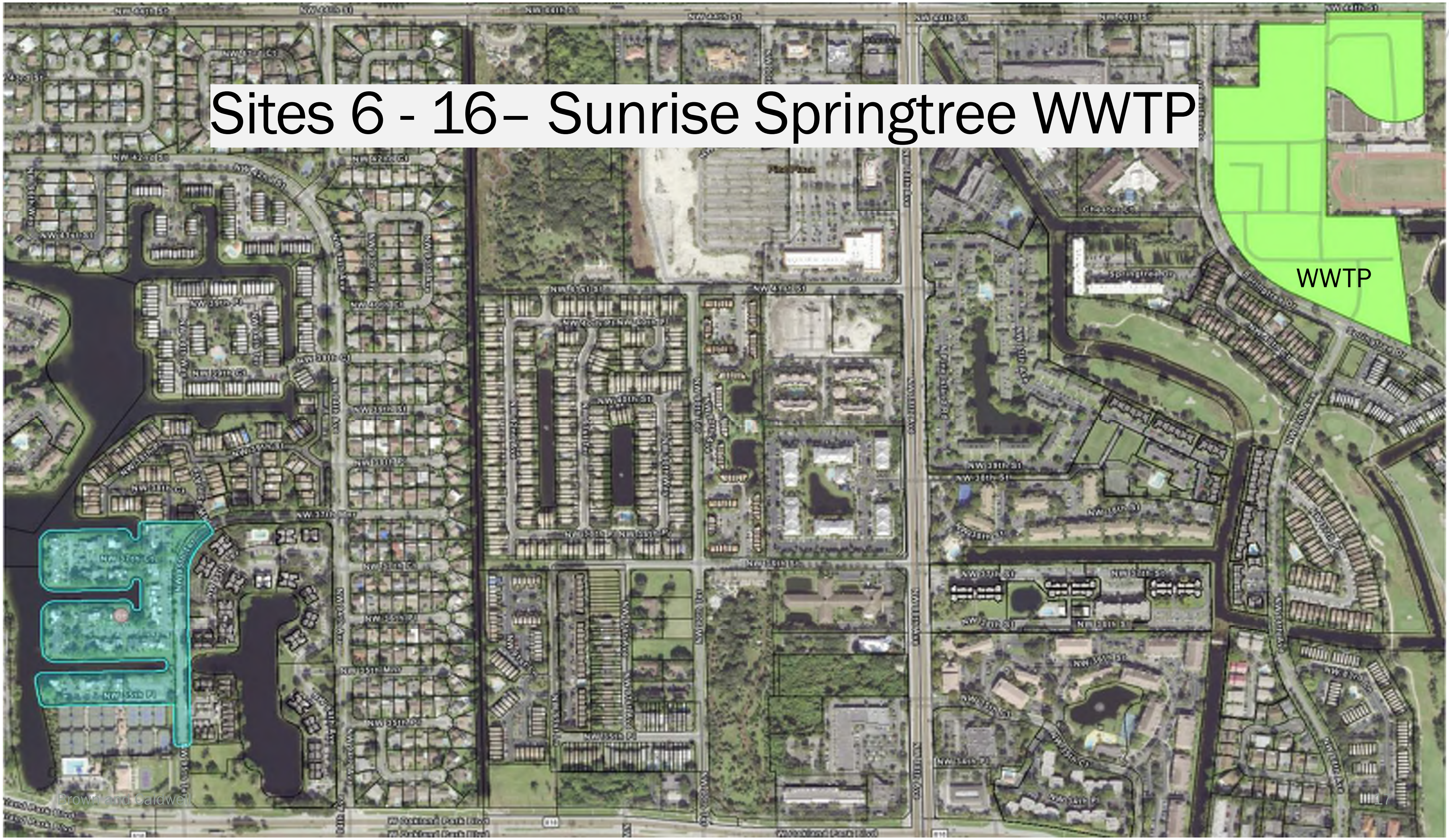


Vacant Government within 1 mile from a WWTP (16 total sites)

Government Owned Vacant Sites Within a Mile of a WWTP		
Site #	**WWTP Utility Name**	**Folio**
1	City of Margate WWTP	484125030010
2	City of Hollywood WWTP	514203690020
3	City of Margate WWTP	484135012670
4	City of Fort Lauderdale WWTP	504223000420
5	Broward County WWTP	484221120050
6 to 16	City of Sunrise (Springtree WWTP)	494120AB0010; 494120AB0020; 494120AB0030; 494120AB0040; 494120AB0050; 494120AB0080; 494120AB0090; 494120AB0150; 494120AB0160; 494120AB0190; 494120AB0200

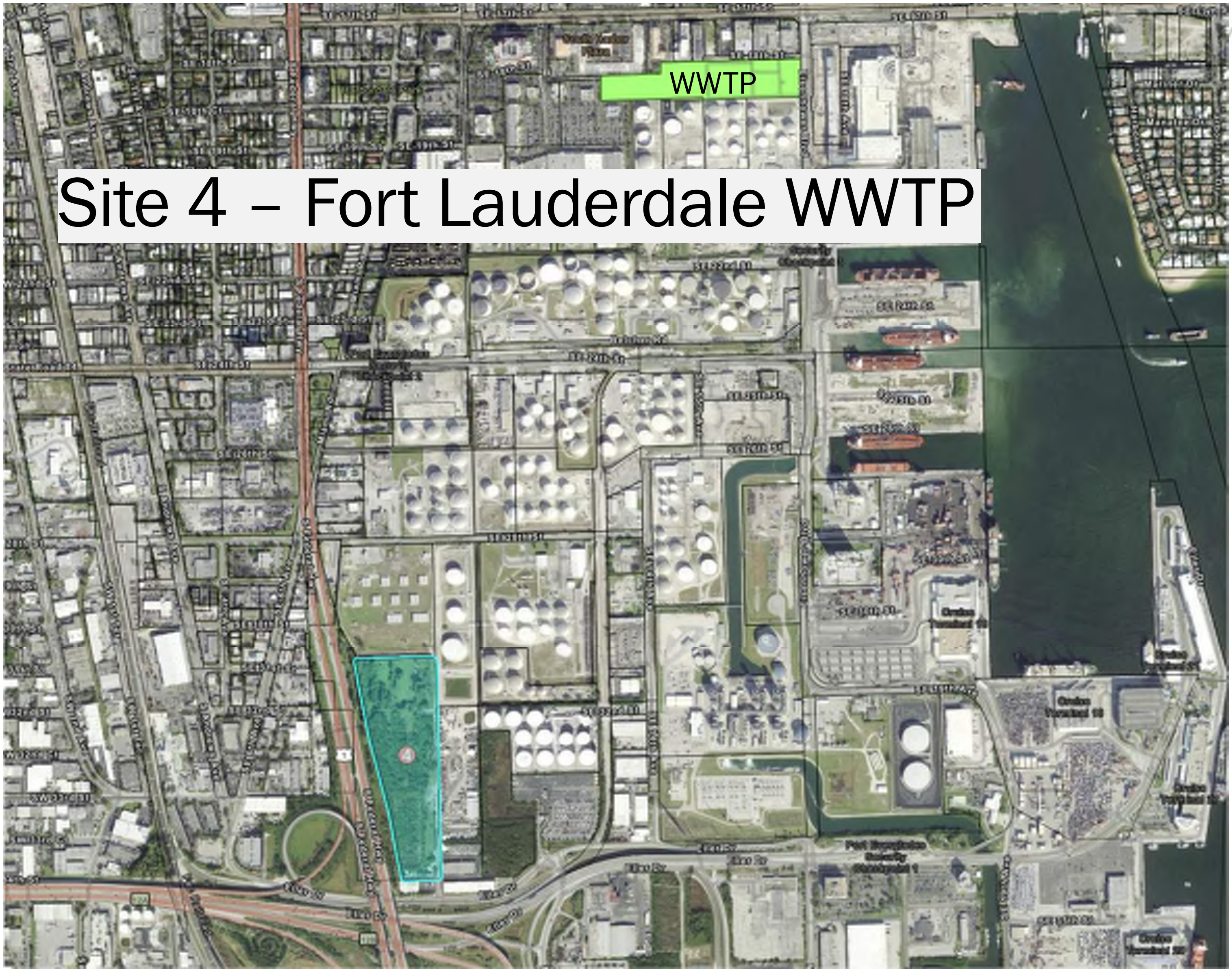


Sites 6 - 16– Sunrise Springtree WWTP

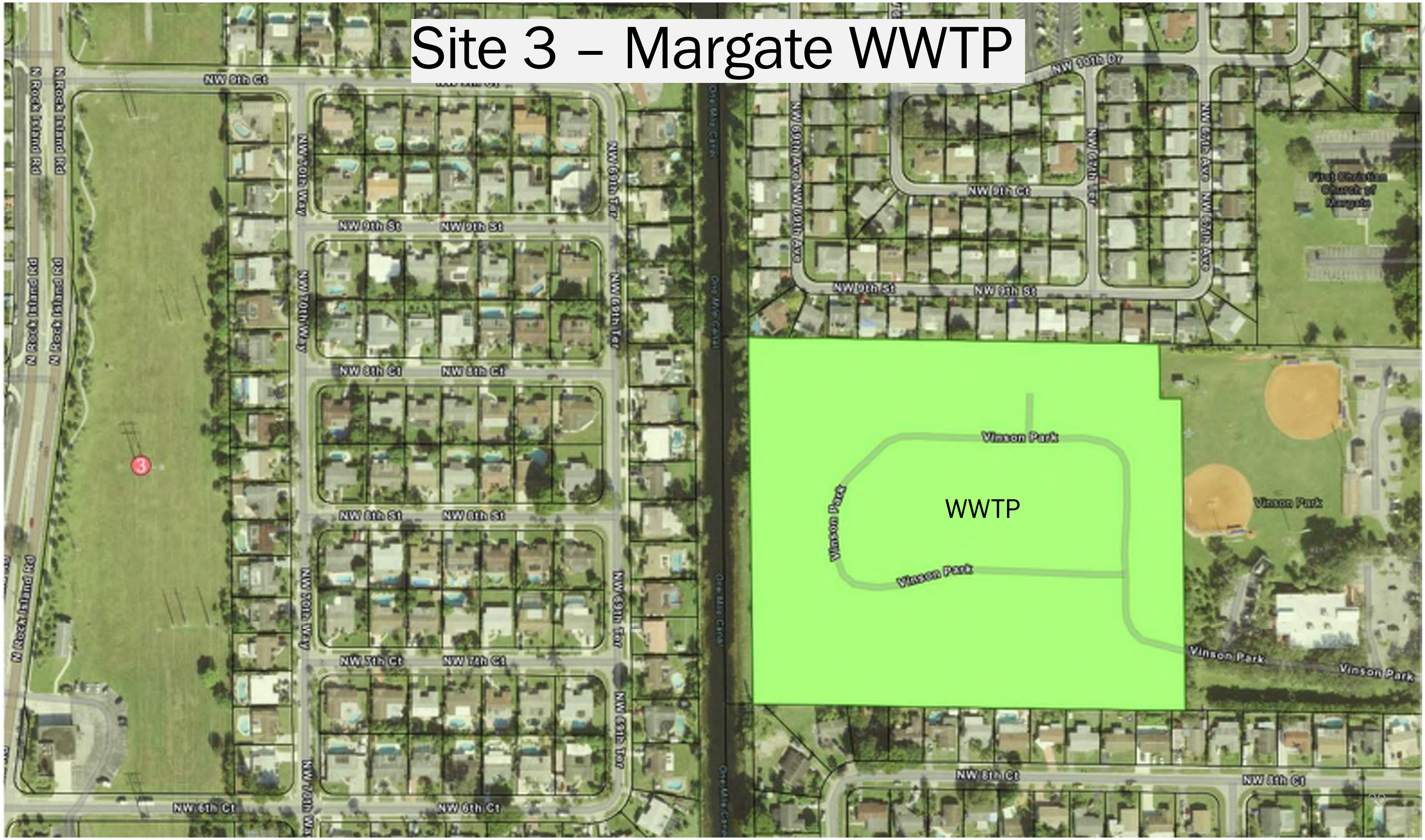


Site 2 – Hollywood WWTP

Site 4 – Fort Lauderdale WWTP

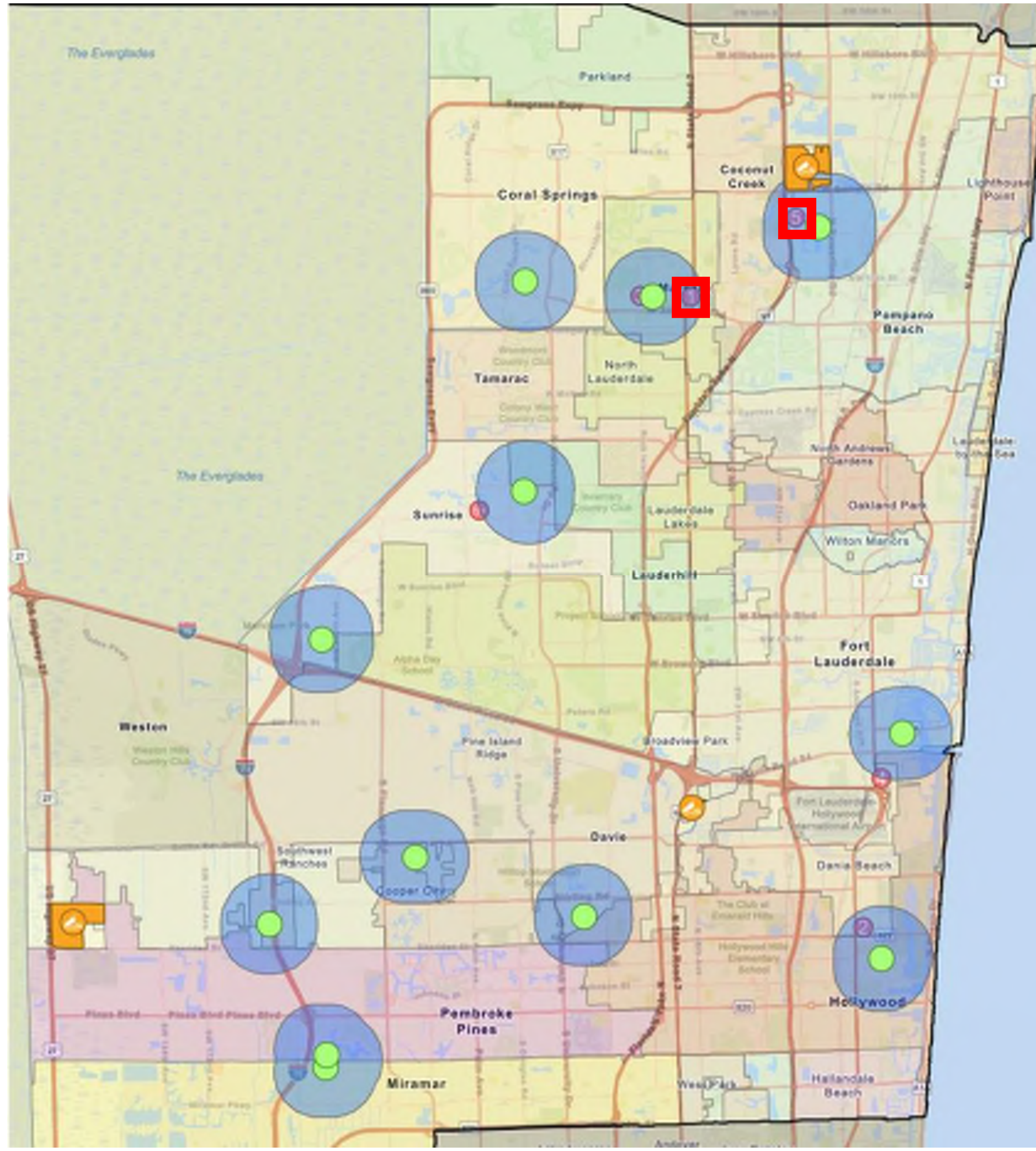


Site 3 – Margate WWTP



Vacant Government within 1 miles from WWTP (16 total sites)

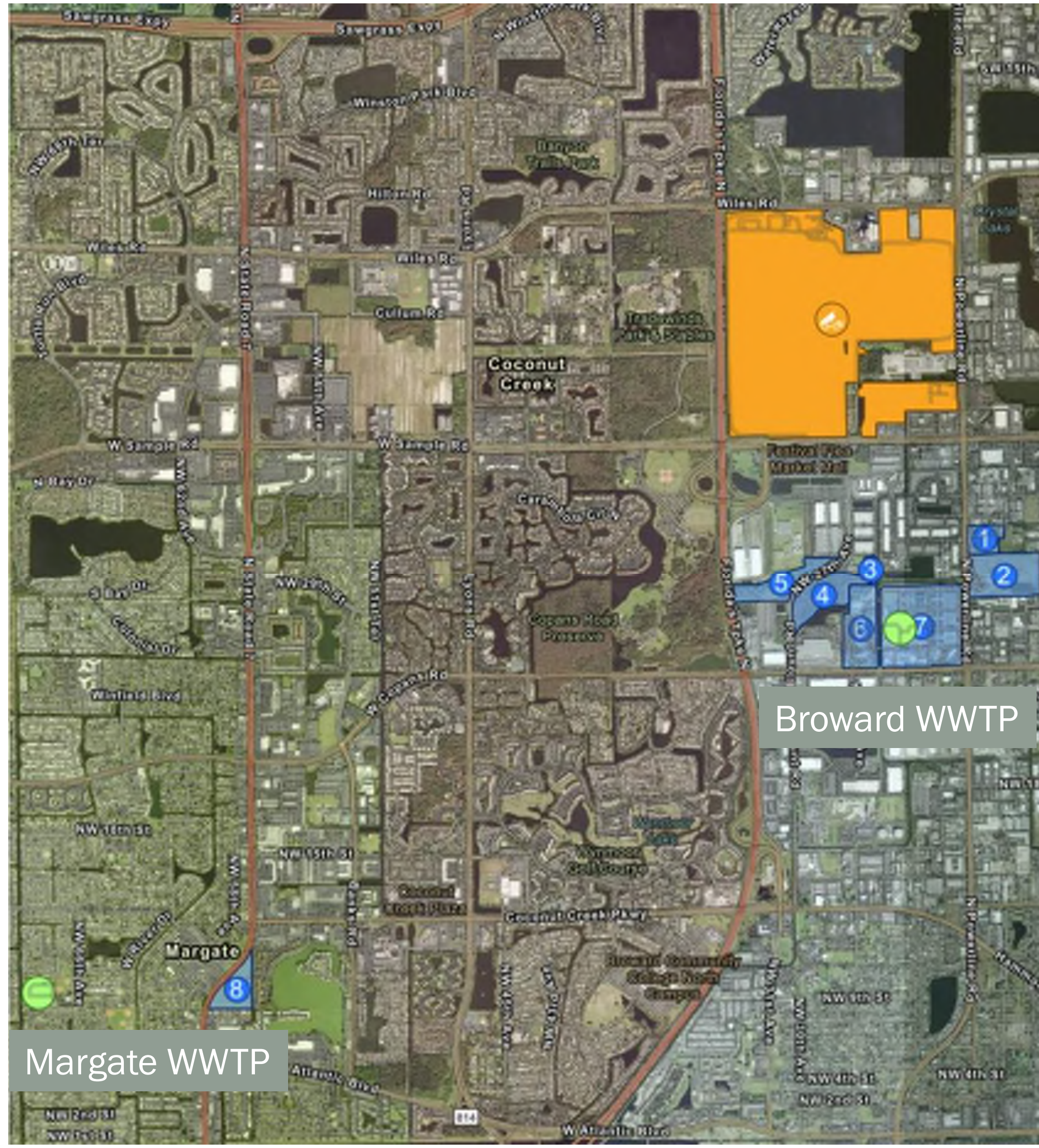
Potential Government Owned Vacant Sites Within a Mile of a WWTP		
Site #	**WWTP Utility Name**	**Folio**
1	**City of Margate WWTP**	**484125030010**
~~2~~	~~City of Hollywood WWTP~~	~~514203690020~~
~~3~~	~~City of Margate WWTP~~	~~484135012670~~
~~4~~	~~City of Fort Lauderdale WWTP~~	~~504223000420~~
5	**Broward County WWTP**	**484221120050**
~~6 to 16~~	~~City of Sunrise (Springtree WWTP)~~	~~494120AB0010; 494120AB0020; 494120AB0030; 494120AB0040; 494120AB0050; 494120AB0080; 494120AB0090; 494120AB0150; 494120AB0160; 494120AB0190; 494120AB0200~~



Potential Available Sites

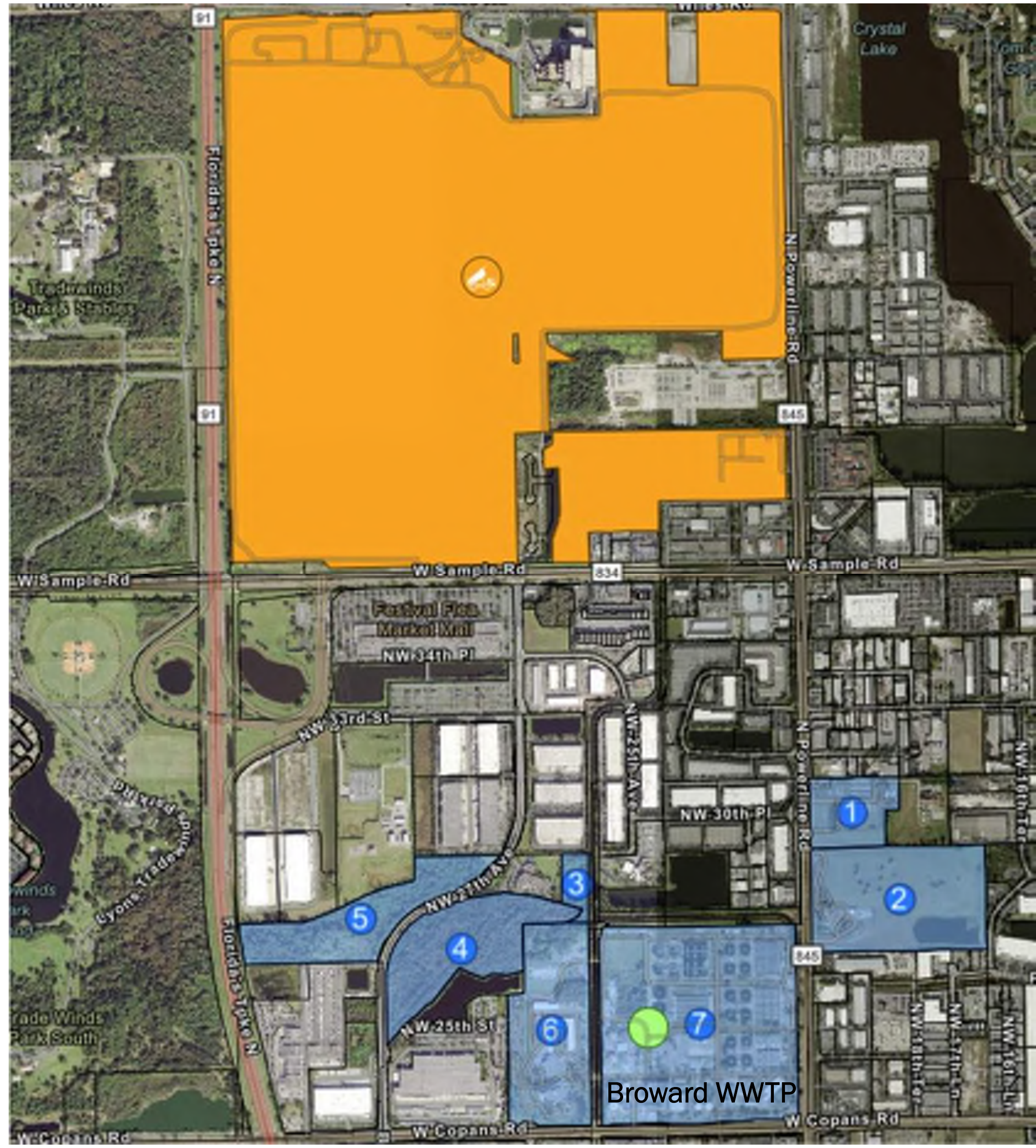
- Sites Meeting New Criteria:
  - 8 Potential sites

Site #	WWTP Utility Name	Area	Distance (miles) to:	
		(Acres)	WWTP	Landfill
1	Broward County WWTP	11.39	0.15	0.55
2	Broward County WWTP	36.58	0.03	0.69
3	Broward County WWTP	3.21	0	0.57
4	Broward County WWTP	25.39	0	0.65
5	Broward County WWTP	22.06	0.13	0.57
6	Broward County WWTP	30.99	0	0.71
7	Broward County WWTP Site	77.09	WWTP	0.72
8	City of Margate WWTP	17.01	0.72	3.35



Top Ranked Sites

Site #	WWTP Utility Name	Area	Distance (miles) to:	
		(Acres)	WWTP	Landfill
1	Broward County WWTP	11.39	0.15	0.55
2	Broward County WWTP	36.58	0.03	0.69
3	Broward County WWTP	3.21	0	0.57
4	Broward County WWTP	25.39	0	0.65
5	Broward County WWTP	22.06	0.13	0.57
6	Broward County WWTP	30.99	0	0.71
7	Broward County WWTP Site			0.72



Delivery Models

Brown AND Caldwell

A key goal of the workshops is to identify trade-offs between governance scenarios

Track 1 – Utility Control

Track 2 - Participation in an Existing Regional System

Track 3 – Public/Private Partnership

Draft list of influencing factors, and we want to make sure we are picking up everything that we need to.

- Permitting complexity
- Organization/staffing
- Stakeholder management
- Funding and financial management
- Project delivery mechanisms
- Integration with existing systems
- Liability/contractual obligations and impacts
- Resource planning impacts

Others?

Partnership Development

Role of Champions

Maintain close contact with counterparts at all partner entities

Build upon foundation of existing staff relationships to increase trust and alignment between partners

Generate enthusiastic support for Regional Biosolids Management System

Identify key issues and potential conflicts

Serve as resource for grant funding, stakeholder outreach, and other internal/external communications

Partnership Development

Potential next steps to help you move forward

- Develop draft roadmap on how to convene meetings and briefings with partners over next few months
  - Develop matrix of partners, including key decision makers and drivers for each
  - Determine what questions need to be asked in 1:1 conversations

- Schedule briefing with key members of executive teams to get comments and questions on potential scenarios

- Outline ongoing related efforts and continue joint workshops with consultant teams to inform and solidify scenario selection

Permitting/ Environmental Complexities

Permitting/ Environmental Complexities

Impact to existing permits, timeline, administrative or operational burden and uncertainty of approval.

Permitting Considerations and Key Takeaways

Time

How quickly do you want the project implemented?

Is time of implementation/ startup more important than future operational flexibility/cost savings.

Shared Liability/ Enforcement

Is the shared liability/enforcement comfortable for all partners with each governance structure?

What agreements are in place/what agreements are on the way?

Future Planning and Flexibility

Permitting strategy includes short-term permit approval for project and long-term compliance for partners – there are constraints, but multiple ways to get there!

Current concerns regarding existing permits?

Funding & Financing

Funding

Process to acquire money to pay for a specific project (planning, design and construction)

Financing

Method used to acquire and manage financial resources (e.g. managing cash flow, acquiring assets and managing debt)

Revenue streams to cover debt repayment, O&M costs, risk management reserves, other

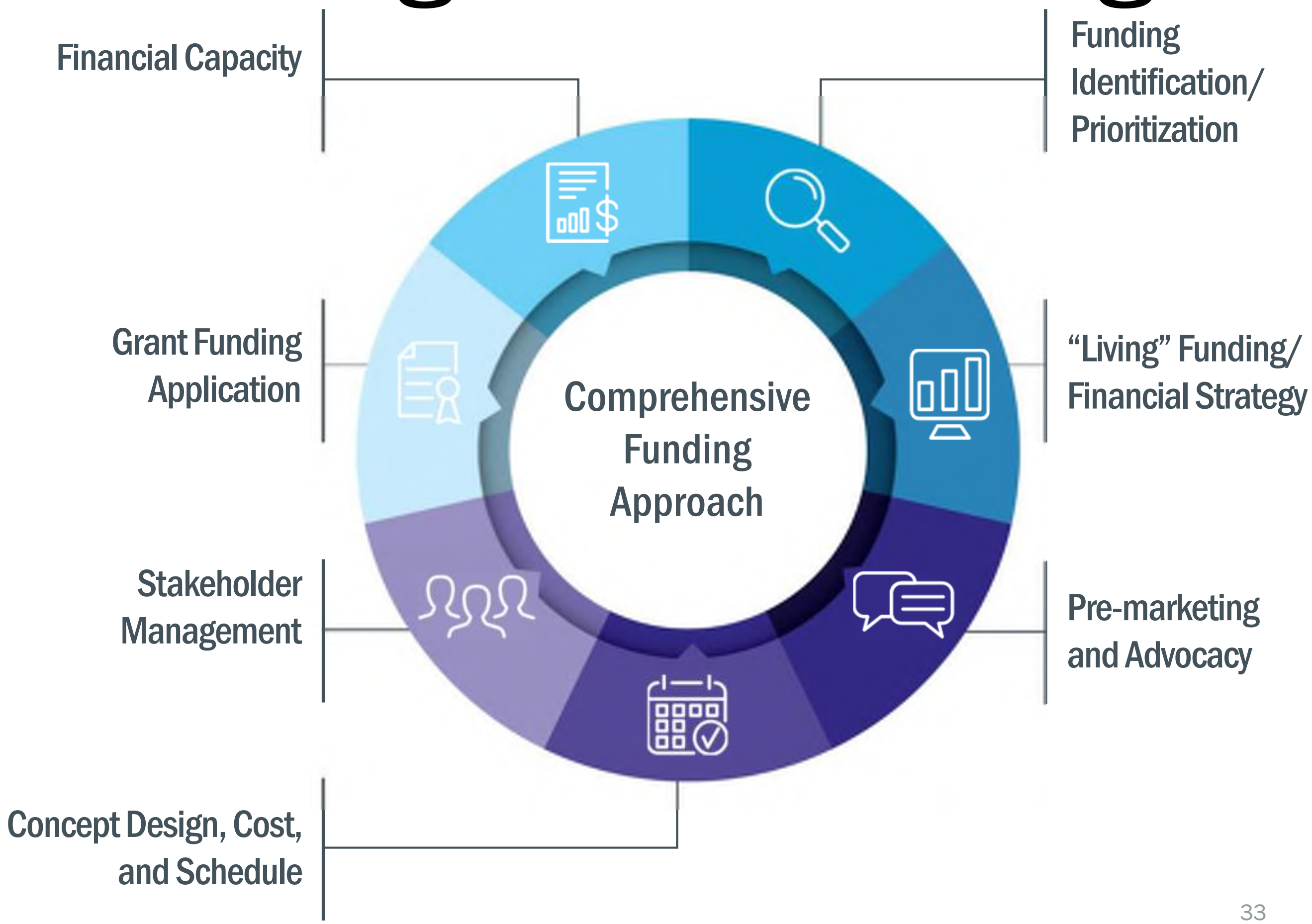
Slide 32

SC0 [@Earl Wilson] please make look nicer
Seema Chavan, 2023-09-26T07:31:43.960

KR0 0 Keep both on both title slide and grey out the one that isn't being discussed (Karla)
Karla Richards, 2023-09-26T19:20:14.101

Funding and Financing

- ID potential external funding opp-ortunities by phases
- Understand Utility financing capacity
- Preliminary Cashflow planning
- Grant applications for planning and design efforts
- Rate study for program



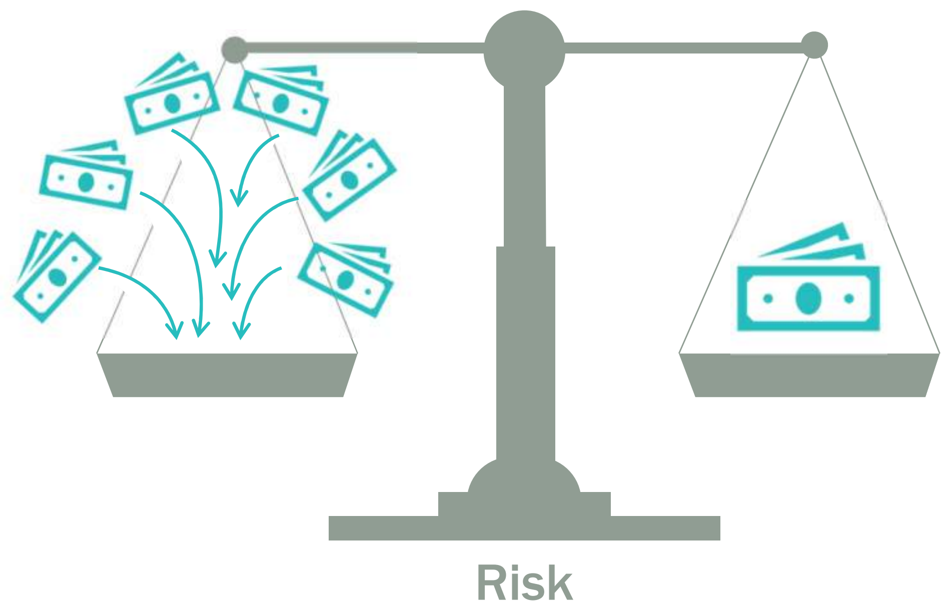
Financing // Net Capital Financing Options

Each Member Responsible for its Share of Capital Costs
- Direct Partner Risk Sharing
- WIFIA Eligible
- Schedule/Efficiency Challenges

Single Utility Finances Capital Costs
- Risk Sharing via Service Agreements
- WIFIA Eligible
- Schedule/Efficiency Positive

New Regional Entity Finances Capital Costs
- Risk Sharing via Service Agreements
- WIFIA Eligible
- Schedule Challenges

Public Private Partnership (P3)
- Risk Sharing via Service Agreements
- WIFIA Eligible?



Finance // O&M Cost Recovery

Fixed Partner Shares

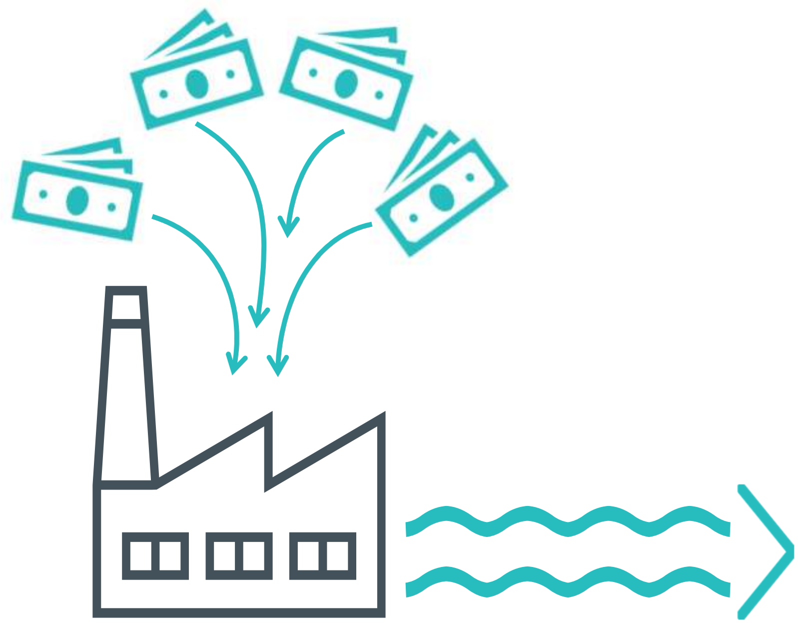
Long-term Capacity Commitments
Periodic Update
Annual Operating Budget
Actual Costs

Public Private Partnership

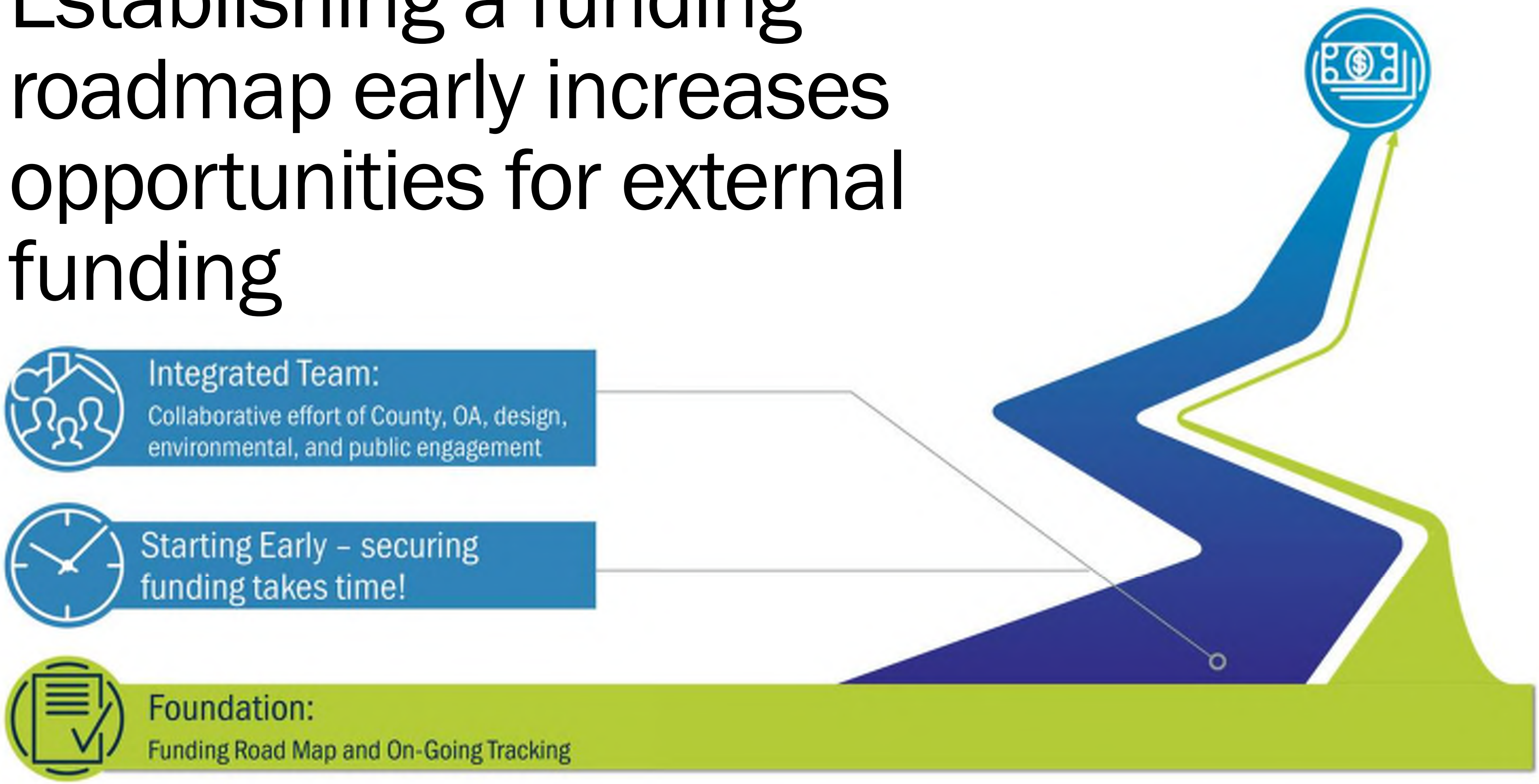
Capital Cost covered by P3
Recovery cost through Long Term O&M
Product Disposal Sales

Commodity-based Recovery (Rates)

Actual Volumes Taken
Take or Pay Minimum
Annual Operating Budget (Prospective)
Actual Costs (Prospective with True Up)
Rate for Non-Partner Customers



Establishing a funding roadmap early increases opportunities for external funding



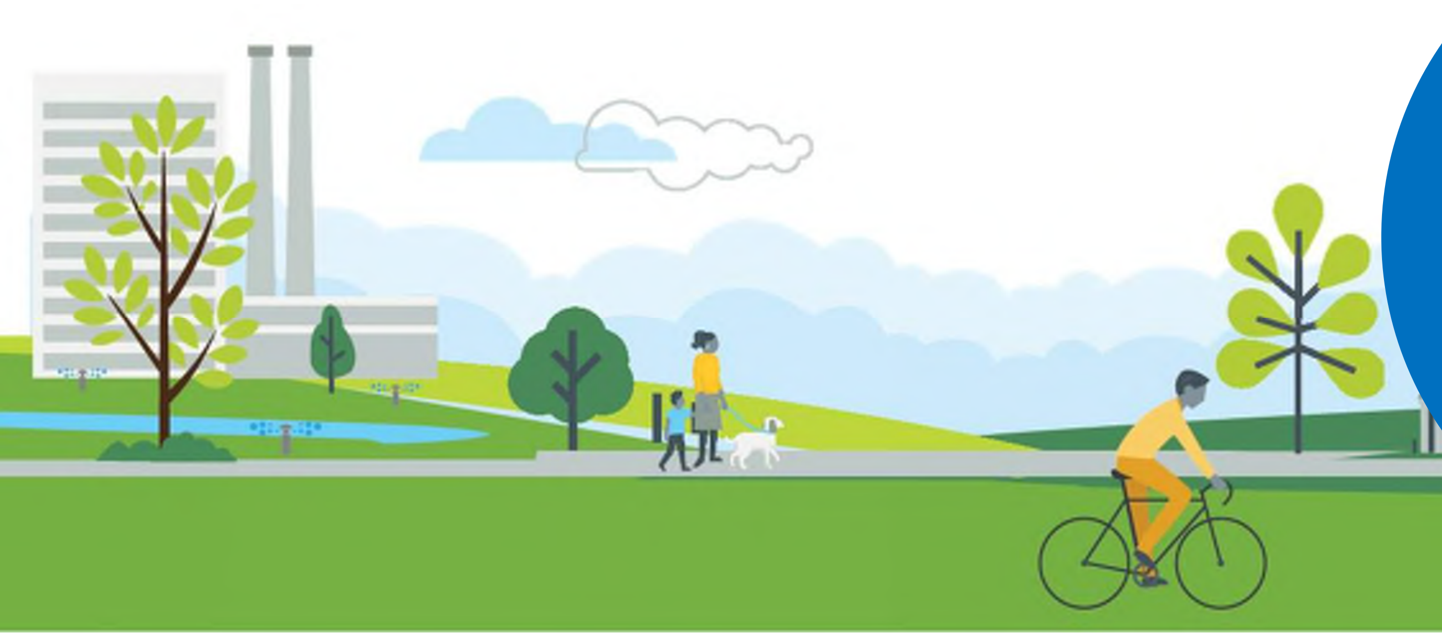
Liability/ Contractual Obligations and Impacts

How administrative burden, risk, or impact to existing obligations or contracts would be expected.

Liability/Contractual Obligations and Impacts

Changes to flow regimes, now and under changing conditions

Agreement complexity between partners to define obligations, finances and decision-making authority



Support for Partner Agreement Discussions

In-Meeting:

Frameworks for Agreement Discussions

Data and educational tools

Pathways/framework for continual advancement of agreements

MOU direction

Key Takeaways

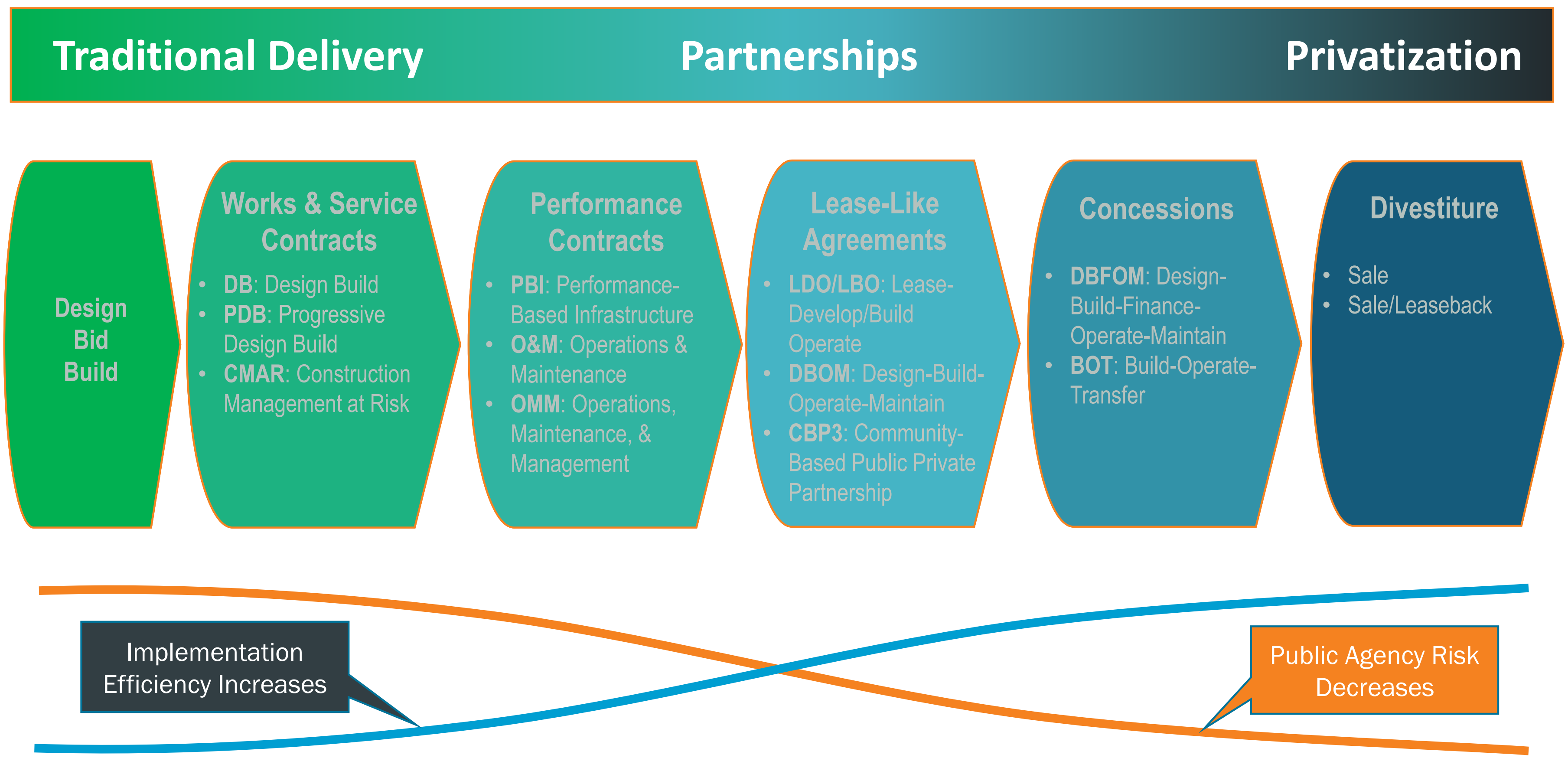
Strategic Partner Engagement is key to successfully bringing along partners and stakeholders early on and ongoing

Determine who is in the drivers' seat to develop a liability framework that is in line with your risk tolerance

Technical integration applies across all scenarios, but presents more risk under some scenarios

There are many schedule interdependencies that require a firm project definition to specify in detail

Continuum of Delivery Approaches



"What exactly is a P3?"

Public-Private Partnerships for Water and Wastewater Infrastructure Projects

This chapter focuses on understanding the fundamentals of the public-private partnership model as they apply to water and wastewater projects. A public-private partnership, often referred to as P3, typically involves a form of collaborative delivery with financing support, combined with a performance commitment and some level of responsibility for operations and maintenance of a capital works project. P3s almost always embed collaborative delivery (as defined in Chapter 2) for the design and construction of a project. P3s also typically expand the collaboration model by including long-term operations, maintenance, repair, and refurbishment of capital projects.

Currently, there is no uniformly accepted definition of P3 in the water/wastewater market sector. For example, water/wastewater P3s may—or may not—include financing or long-term operations. As such, this chapter necessarily covers a range of P3 models. And unless otherwise noted, the most common P3 model (where the private sector design, builds, finances and provides some form of operations and maintenance and a public entity owns the infrastructure) is generally assumed. For the purpose of this Handbook, what is common to all envisioned P3 water and wastewater projects is the integration of collaborative-delivery methods.

An Evolving Definition for Water:
<u>Three Key Elements</u>

1. Some form of financing
   and/or
   long-term operations
2. Performance commitments
3. Embedded design-build

“Fundamental P3 Concepts”

Understanding P3s for Water:
Three Key Concepts

Value for Money

Higher private financing costs should be offset by:

- Certainty of performance
- Efficiency
- Innovation

Risk Transfer

Third-party funding creates a mechanism for:

- Multiple layers of securitization
- Reward – and penalties – for performance
- Defined delivery responsibility

Delivery Structure

Project structure reflects contractual commitments:

- Project Company or SPE is signatory to Owner
- Equity and debt ultimately responsible for performance
- Design-build entity at the delivery level

An Evolving Definition for Water:
Three Key P3 Elements

1. Some form of financing
   and/or
   long-term operations
2. Performance commitments
3. Embedded design-build

"Risk Transfer"

Water-Sector Risk Issues

Owner's Risks

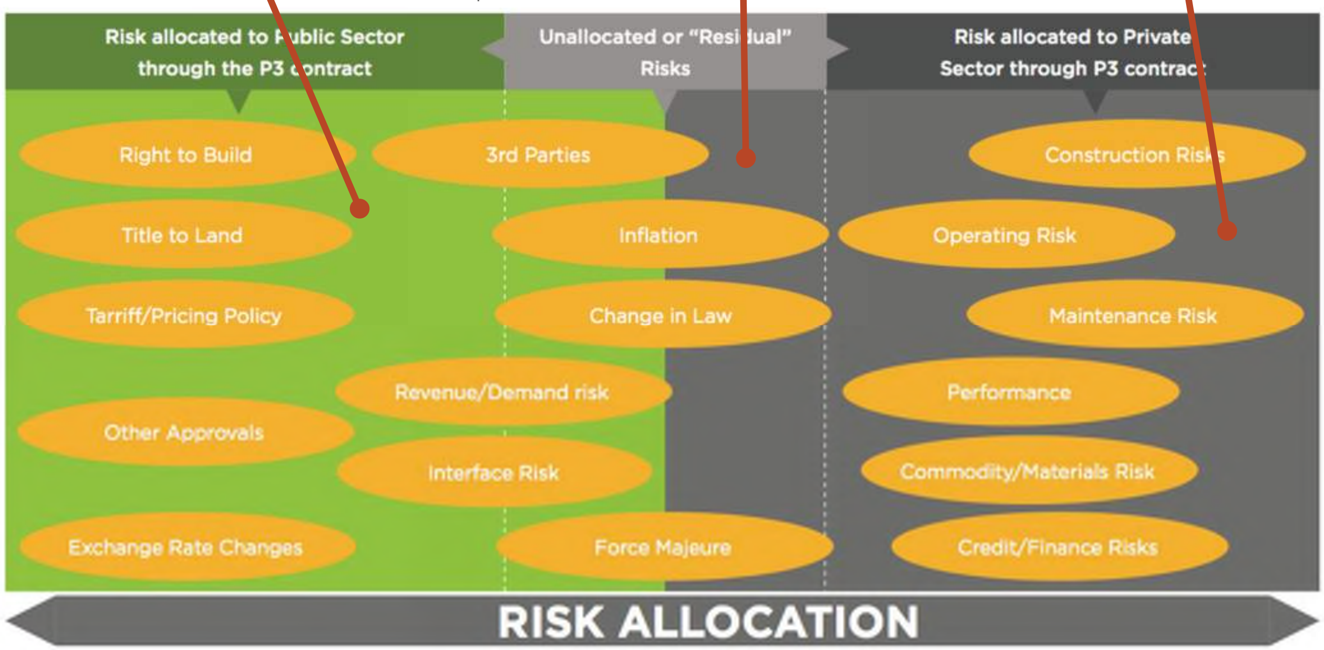
- Ultimate responsibility for public health protection
- Holder of discharge and other regulatory permits
- O&M integration within a large, complex system
- Legacy staff; privatization opposition

Unallocated Risks

- Pressure: shift to the right
- Complex commissioning and start-up for treatment processes
- Lifecycle accountability difficult to shift without long-term O&M
- Frequent change in regulations
- High ratio: O&M to capital costs

P3's Risks

- Ability to quantify a variable treatment regime
- External/political opposition to P3
- Variability in repair and replacement methodology and requirements
- External factors affecting treatment
- Limited market for O&M redundancy



Next Steps

Congratulations TEAM

Congratulations to the entire team for achieving remarkable progress on this project! Your dedication and hard work to this process has truly propelled this project forward! Here's to the journey ahead and the success yet to come!

Everyone take a bow!

Brown AND Caldwell

Next Steps

Activity	Description	Date
Draft Deliverable	Draft report provided to the Participating Utilities for review	March 13, 2024
Comments Due	Comments due on Draft Report	March 27, 2024
Meeting 7	Phase 3 Recommendations & Report Review	April 3, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Thank you.

– Questions?

Brown AND Caldwell

Brown AND Caldwell

Brown AND Caldwell

Regional Biosolids Solution Study

Work Authorization No. BC 19-25, Broward County

April 10, 2024

Agenda

Workshop 7: Recommendations & Report Review

- Welcome & Introductions
- Project Overview
- Regional Biosolids Plan
  - Summary
  - Comments Overview
  - Elevator Speech
- Next Steps Roadmap
- Final Current Project Milestones

Welcome and Introductions

Name	Organization
Trevor Fisher	Broward County
Alan Garcia	Broward County
Mark Darmanin	Broward County
Rolando Nigaglioni	Broward County
Carlos Garcia	Broward County
Tiffany Bacon	Broward County
Maria Loucraft	Broward County
John Kay	Broward County
Shae Hutchinson	Broward County
Raj Verma	City of Cooper City
George Garba	City of Cooper City
Mike Aldrich	City of Cooper City
Joe Stephens	Coral Springs Improvement District
David McIntosh	Coral Springs Improvement District
Mike Hosein	Coral Springs Improvement District
Renuka Mohammed	Town of Davie
John McGeary	Town of Davie
Talal Abi-Karam	City of Fort Lauderdale
Melissa Doyle	City of Fort Lauderdale
Todd Hiteshew	City of Fort Lauderdale
Miguel Arroyo	City of Fort Lauderdale
Vincent Morello	City of Hollywood
Jeff Jiang	City of Hollywood
Keith Bazile	City of Hollywood
Ali Parker	City of Hollywood
Glen Superville	City of Hollywood
Curt Keyser	City of Margate
Marta Reczko	City of Margate
Wendell Wheeler	City of Margate

Name	Organization
Rolando Taylor	City of Miramar
Francois Domond	City of Miramar
Ronnie Navarro	City of Miramar
Jinsheng “Jin” Huo	City of Miramar
Denis Marcelin	City of Miramar
Eric Francois	City of Miramar
Bruce Tross	City of Miramar
Anthony Parish	City of Miramar
Shelanda Krekreghe	City of Miramar
David Interiano	City of Miramar
Michael Bailey	City of Pembroke Pines
Paul Thompson	City of Pembroke Pines
Victor Leon	City of Pembroke Pines
Dan Pollio	City of Plantation
Steve Peraza	City of Plantation
Jules Ameno III	City of Plantation
Tim Welch	City of Sunrise
Sangeeta Dhulashia	City of Sunrise
Ted Petrides	City of Sunrise
Donald Maddox	City of Sunrise
Marie Burbano	Brown and Caldwell
Tracy Chouinard	Brown and Caldwell
Joanna Julien	Brown and Caldwell
Albert Perez	Brown and Caldwell
Sydney Salit	Brown and Caldwell
John Willis	Brown and Caldwell
Mark Drummond	C-Solutions

Project Overview

Brown AND Caldwell

Background

- South Florida uses a mix of land application & landfills for biosolids disposal
- Future of biosolids handling and disposal is uncertain in view of:
  - Decreasing landfill space
  - Decreasing # of potential land application sites
  - Community opposition to land application
  - Increased costs of land application
  - Regulatory uncertainty concerning biosolids disposal
- **This group came together to explore regional solutions**
- A regional approach could result in:
  - Economies of scale
  - Shared resources
  - Multi-jurisdictional public support
  - Diversify disposal options and decrease risk

Overall Project Plan

– Structured, cooperative framework that results in decisions that are **transparent and defendable with consensus**

Data Gathering and Analysis

- Data Collection & Evaluation
- Projections of Future Conditions
- Regulations
- Market Analysis
- Team provides data

Alternatives Evaluations

- Technology
- Site Assessment
- Delivery Model
- Team provides input and participates in evaluation

Regional Biosolids Plan

- Report to convey key findings, promising alternatives, uncertainties & next steps
- Planning document aligned with Team expectations and future vision

Phase 1

Phase 2

Project Schedule

Activity	Description	Date
~~NTP~~	~~Notice to Proceed~~	~~May 4, 2023~~
~~Meeting 1~~	~~Kickoff, Data Request~~	~~May 24, 2023~~
~~Meeting 2~~	~~Data analysis summary, Projection of Future Conditions~~	~~July 26, 2023~~
~~Meeting 3~~	~~Review of Rules and Regulations and Market Assessment~~	~~September 27, 2023, 2pm to 4pm~~
~~Meeting 4~~	~~High level alternatives analysis for four (4) alternatives using SWEET model, select two (2) for further consideration~~	~~November 1, 2023, 2pm to 4pm~~
~~Meeting 5~~	~~Review of two (2) alternatives, refined SWEET Model~~	~~December 13, 2023, 2pm to 4pm~~
~~Meeting 6~~	~~Site assessment and delivery models~~	~~February 7, 2024, 2pm to 4pm~~
~~Draft Deliverable~~	~~Draft report provided to the Participating Utilities for review~~	~~March 13, 2024~~
~~Comments Due~~	~~Comments due on Draft Report~~	~~March 27, 2024~~
Meeting 7	Report Review & Next Steps	April 10, 2024, 2pm to 4pm
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Congratulations!

Florida Water Environment Association

wef Member Association

Biosolids/Residuals Program Excellence
Large Operating Facility

Presented to

Broward County Water and Wastewater Services North Regional WWTF

Regional Biosolids Plan Summary

Brown AND Caldwell

State Regulations

Florida Administrative Code Chapter 62-640

Florida Statute 403.0855

[Chapter 403 Section 0855 - 2020 Florida Statutes - The Florida Senate (flsenate.gov)]

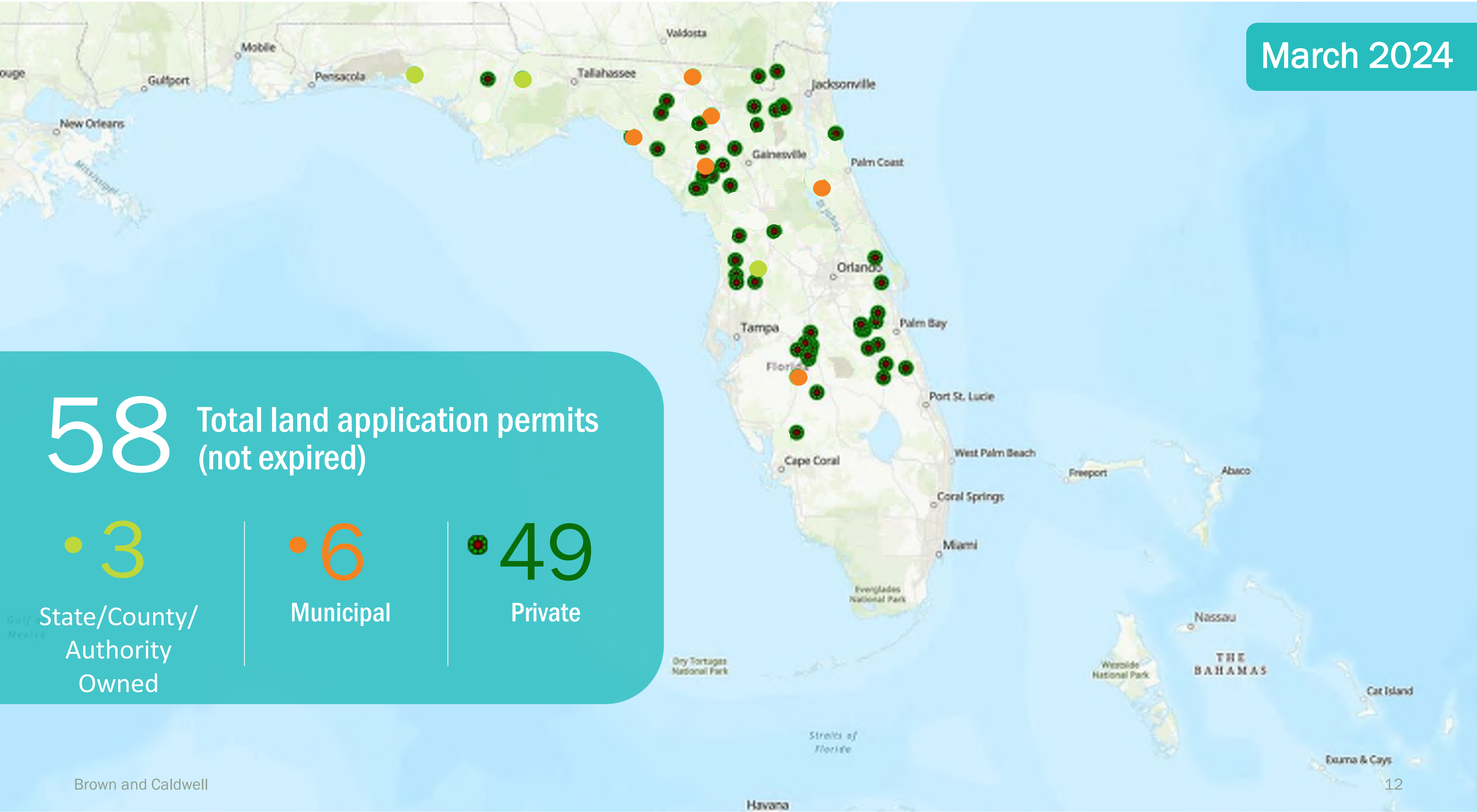
- Effective July 1, 2022. Comply by July 1, 2023.
- FDEP requirement for permitted land application sites for Class-B biosolids must comply with two provisions:
  - Limit nitrogen and phosphorus loading
  - Ensure a minimum unsaturated soil depth of 2 feet between the depth of biosolids and the water table level
- FDEP estimated that 6 to 10 times more acreage was needed for Class B applications.
- Florida Department of Agriculture and Consumer Services (DACS) regulates Class-AA biosolids as fertilizer and compliance is required for a minimum amount of nutrients.

Class B Biosolids

There are currently 58 permitted land application sites in Florida as of March 2024

- 130 sites in 2021, 65 in July 2023
- Many are letting their permits expire with no intention of renewing
- Most permits are held by haulers instead of a utility applying the biosolids themselves

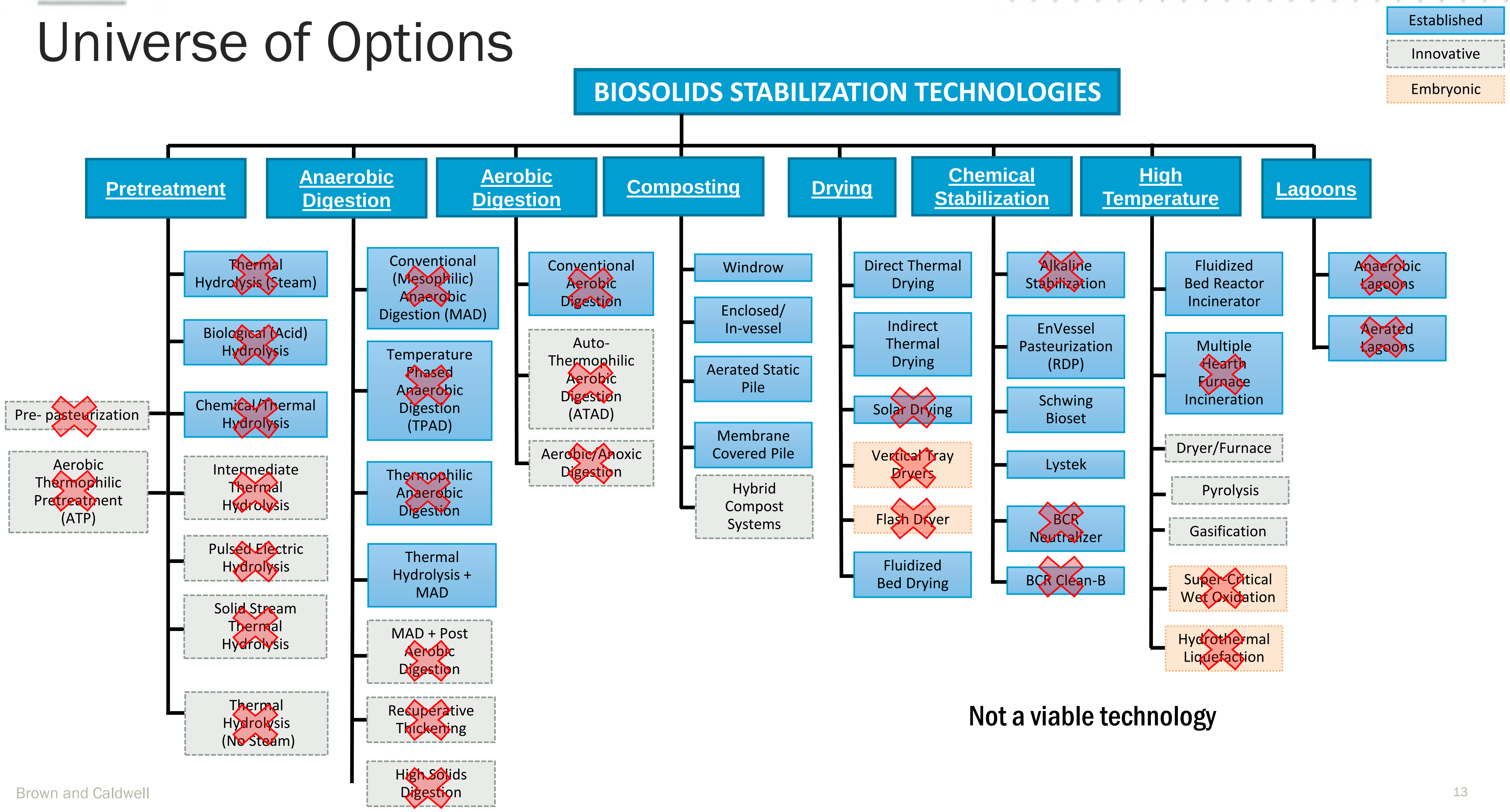
March 2024



58 Total land application permits (not expired)

3	6	49
State/County/ Authority Owned	Municipal	Private

Universe of Options



Short-list of 4 Alternatives

Alternative A
THP

Alternative B
Thermal Dryers

Alternative C
50-acre Composting Facility

Alternative D
Fluid Bed Incineration

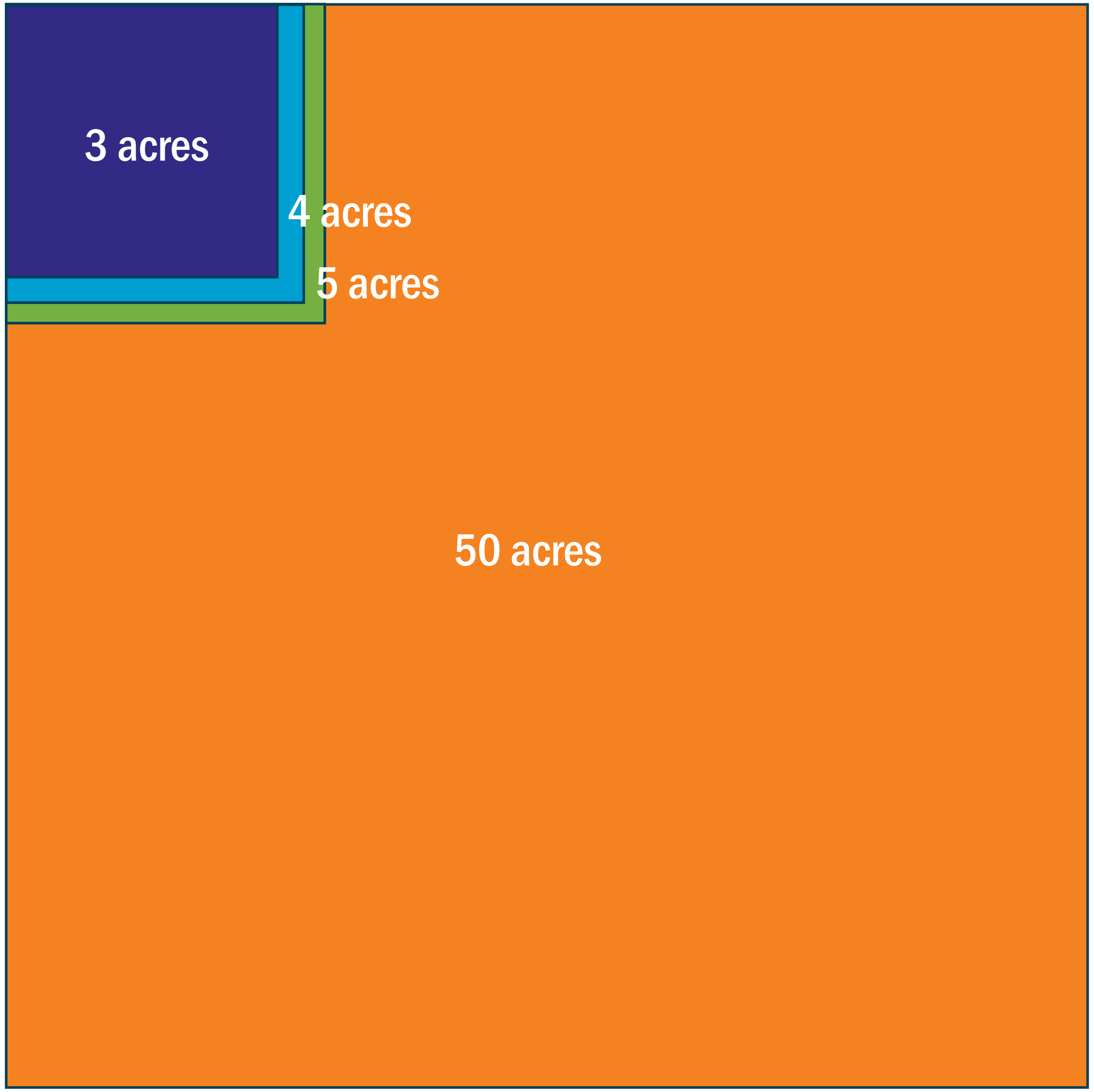
Relative Size by Alternative

Alternative A
THP

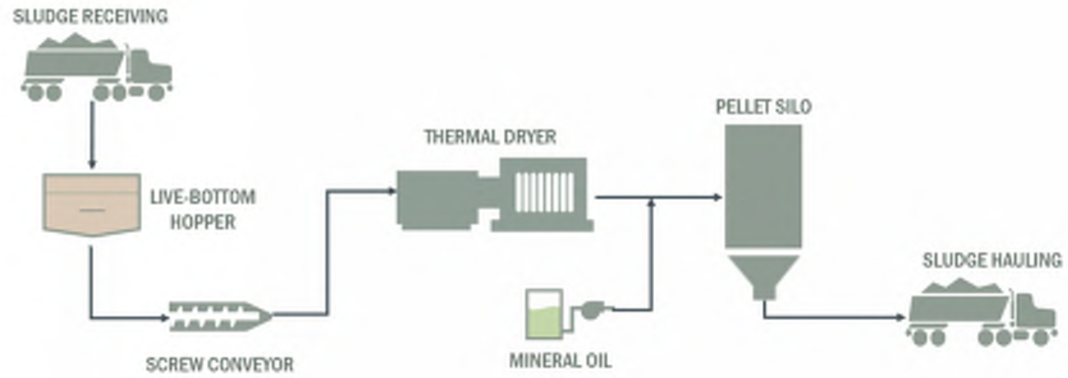
Alternative B
Thermal Dryers

Alternative C
Composting

Alternative D
Fluid Bed Incineration



Selected Alternative: Thermal Drying



Capital Elements

- Sludge receiving station with live bottom hoppers
- Sludge conveyance
- Four – DDS110 Thermal Dryers
- Four RTOs for odor control
- Five pellet silos

Comments Overview

Report Comments

- Responses received to date:
  - City of Plantation
    - What, if any, additional costs will be required up to the final off-ramp?
      - Response: Any additional costs incurred by RBS workgroup members will depend on agreements made during governance agreements. Any fees would be agreed to during this time. Consideration for next phase, no change to current report.
    - Will stakeholders know the full cost before the final off ramp?
      - Response: Stakeholders would have a better (tighter) cost range anticipated by the final suggested off ramp in Figure 9-1. However, the final cost would not be fully developed until after requests for proposals have been received, reviewed, selected, and negotiated. If RBS workgroup members wanted, there could be an off-ramp at this time prior to design and construction. The off-ramps would be specified during governance agreements. Consideration for next phase, no change to current report.
  - Town of Davie
    - Comment on list of participants
      - Response: Will be incorporated in final.
  - City of Miramar
    - Will provide comments at workshop
- Other comments?

Elevator Speech

Why Change How We Manage Biosolids?

- Stringent regulations and availability of landfill space are causing immediate needs
  - New Biosolids Management Rule (Florida Statute 403.0855) became effective July 1, 2022 which led to stricter Class B land application
  - 130 Class B application sites in 2021 became 58 by March of 2024
  - FDEP estimated that 6 to 10 times more acreage will be needed for Class B applications

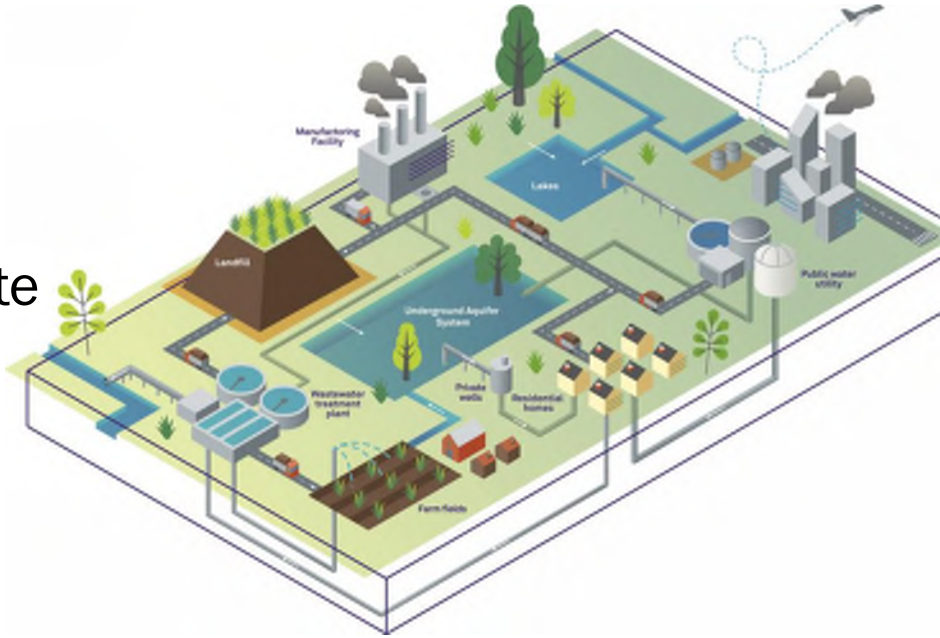
Why Is Thermal Drying the Best Technology To Solve This Problem?

- Thermal drying allows for significant mass reductions and is also the most proven technology
  - Reduces mass by 4-5x
  - Suitable technology to accept biosolids from all participating utilities
  - Hundreds of thermal dryers are in operation since at least the 1950s
  - Palm Beach County SWA has had a successful regional thermal dryer since 2009 that this group was able to tour
    - Established market in Florida already
  - Multiple equipment manufacturers for competitive pricing
  - If PFAS regulation on biosolids is implemented, thermal drying will be first step for biosolids handling for PFAS

Palm Beach County Solid Waste Authority (SWA)

What about PFAS?

- No EPA/FDEP regulations on wastewater and biosolids yet, but monitoring through NPDES permits encouraged
- Biosolids risk assessment process for PFOA and PFOS underway, expected Draft in August and Final in December 2024
- EPA expected to endorse source-control methods to mitigate PFAS, if necessary
- Thermal Dryers and PFAS
  - Currently no commercially available PFAS destruction/mitigation technologies on market with full-scale operational experience.
  - Two most promising technologies: pyrolysis & gasification
    - Sludge drying (including thermal dryers) is the first step for both

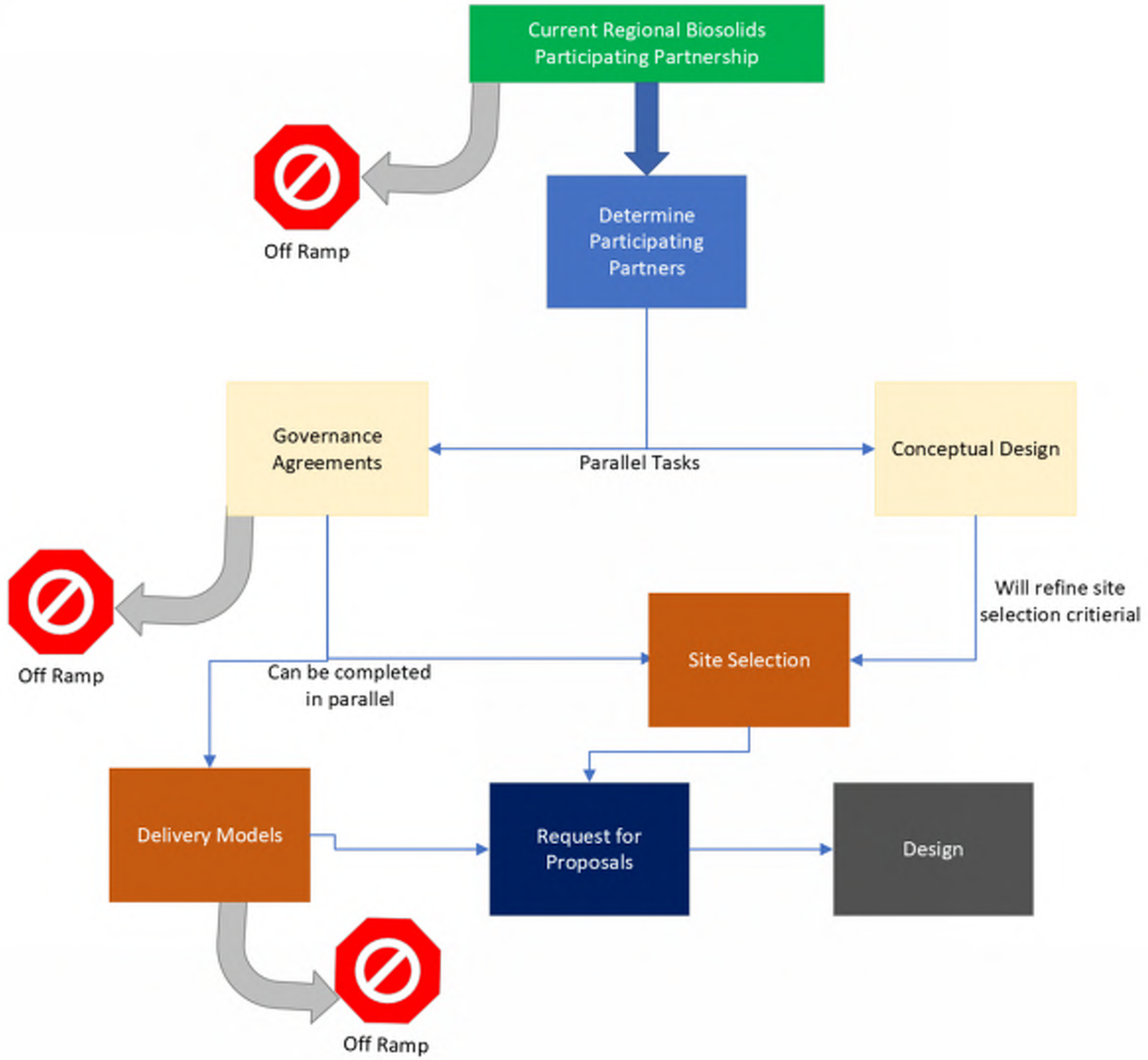


Next Steps Roadmap

Brown AND Caldwell

Next Steps Roadmap

- General concept to move forward
- Several points for utility off ramps
- Letters of interest/intent, Interlocal Agreements (ILAs)



Things to Consider Moving Forward

- Governance Agreements Considerations
  - Who are the stakeholders?
  - Who and how will future decisions be made regarding the regional facility?
  - How will capacity be allocated to each utility now and in the future?
  - If future capacity is allocated now, can a utility “sell” their unused capacity to another entity?
  - What, if any, upfront fees does each RBS Workgroup member need to pay? How are fees and rates equitably determined?
  - If a RBS Workgroup member hosts the facility on their site, do they receive host fees or a reduce rate?
  - Can other Utilities join later? How is the rate determined for those Utilities?
  - Who will be in charge of operating the facility?

Final Current Project Milestones

Brown AND Caldwell

Final Current Project Milestones

Activity	Description	Date
Final Deliverable	Final report to present the findings of all tasks performed	May 1, 2024
Project Completion	Final closeout of project	May 3, 2024

Thank you.

Questions?

Brown AND Caldwell

Brown AND Caldwell

Risk

Community

Cost

O&M

Reliable

Robust

Regulatory

Regional Facility Goals/Objectives

- Create diversity in end use markets (Class AA product)
- Minimizes neighborhood impacts (odors and traffic)
- Minimizes footprint requirements to achieve objectives
- Life-cycle cost
- Reduce biosolids volume
- Reuse biosolids beneficially (resource recovery)
- Provide flexibility and scalability to meet future regulations
- Ease of operation and maintenance
- Maintain or improve current carbon footprint
- Proven & reliable technology
- Reduced regulatory oversight/paperwork
- Redundancy
- Permittable (including length of permitting time)

Attachment B: Technology Overview

Attachment B

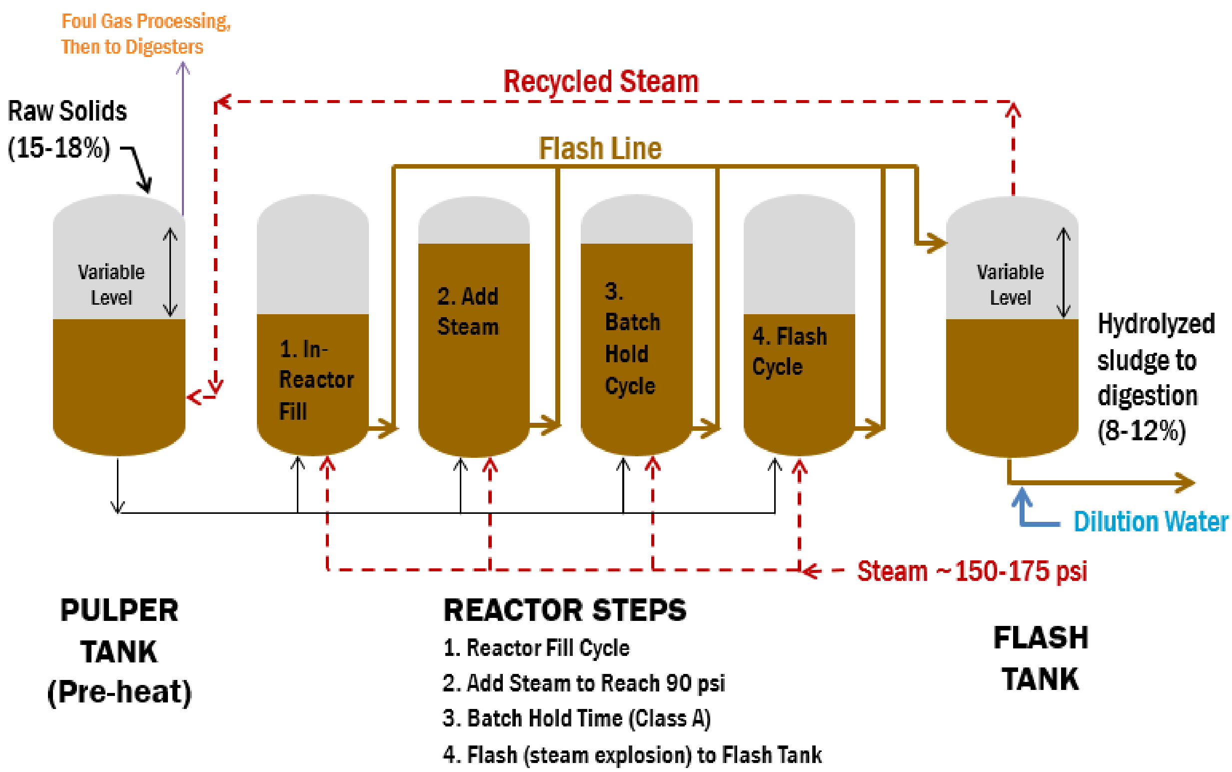
UNIVERSE OF OPTIONS TECHNOLOGY OVERVIEW

Contents

B-1. Thermal Hydrolysis

Classification: Pre-Treatment.

Description: Thermal hydrolysis process (THP) can be installed upstream of anaerobic digestion either between anaerobic digestion stages or downstream of anaerobic digestion (noting that post-pasteurization is not allowed in the United States). For the purposes of this analysis, THP is proposed in its most common configuration—as a pretreatment system to anaerobic digestion, which results in more efficient sludge processing and energy production. THP uses medium-pressure steam to create high temperature and pressure conditions. These conditions lyse bacterial cells and promote the release and solubilization of particulate organic material, which makes the feed solids more amenable to digestion. Cambi™ THP, the most commonly installed THP, generates Class A biosolids that are effectively pathogen free due to the sterilizing pretreatment conditions. Pre-digestion THP can also be applied to WAS only (excluding primary sludge). THP systems dedicated to WAS can reduce capital costs while still realizing most of the digestion capacity and dewaterability benefits; however, Class A biosolids are not created.



Cambi™ Thermal Hydrolysis Process

THP improves digestibility by hydrolyzing large biological macromolecules, carbohydrates, and long-chain fatty acids to reduce molecular weight. This process increases the rate of digestion, which allows for a reduced digester residence time while also increasing the extent of volatile solids reduction and gas production by about 10 to 20 percent. Additionally, THP decreases the viscosity of the digester feed sludge, which allows the feed solids concentration to be in the range of 9 to 12 percent TS rather than a conventional range of 4 to 6 percent TS. This increase in solids, combined with the improvement in digestion rate, increases the volumetric solids loading rate and decreases HRT, which increases the solids handling capacity of a given digester and significantly reduces costs associated with the construction of new digesters. Finally, compared to conventional MAD, the digested solids from a THP system exhibit improved dewaterability and less odorous cake.

For optimal performance, THP requires screening and pre-dewatering of the primary sludge and WAS. This pre-dewatered cake is diluted with preheated water and then preheated using waste steam from the THP process. In the Cambi™ configuration, the solids are heated and pressurized by live steam injection to temperatures ranging from 300°F to 350°F and 80 to 120 pounds per square inch (psi), followed by a batch hold time or reactor residence time of 15 to 30 minutes. The reactor is then depressurized, with the waste steam used to preheat incoming solids. The solids may be exposed to a sudden depressurization step that augments the physical destruction of the solids and improves viscosity and hydrolysis. The solids are diluted with disinfected plant water to approximately 9 to 12 percent TS, cooled, and digested. The cooling process also involves applying a recycle stream from the digesters.

THP systems can approximately double MAD OLRs due to the significantly higher solids concentrations in the digester, i.e., are able to be loaded to approximately 0.400 lb-VS/ft^3-d and operate at a minimum retention time of 12 days. Because of the exceedingly high loading rates and the solids concentrations, the process is limited to a total ammonia-N concentration of less than 3,000 milligrams nitrogen per liter (mgN/L). Because of this limitation, some systems operate at slightly reduced feed solids concentrations. Another unique impact that THP has on plant operations is the generation of refractory nitrogenous compounds. While non-biodegradable, these compounds can impact plant effluent compliance for facilities regulated on a total nitrogen limit. Mitigation strategies may be necessary.

THP also requires a number of support processes and facilities to achieve its high degree of process intensification. This includes sludge pre-screening (<5 millimeters [mm]), pre-dewatering, cake storage, cake pumping, medium-pressure steam boilers, cooling heat exchangers, pathogen-free water systems, and the associated buildings to house these processes. Effectively, the deployment of THP and its high-quality cake product involves trade-offs related to system complexity (Wang et al., 2018).

B-2. Acid Phase Digestion or Biological Hydrolysis

Classification: Pre-Treatment.

Description: Biological hydrolysis is a process that enhances the anaerobic digestion of sludge by pre-conditioning it in a fermenter vessel or vessels, where different environmental conditions favor the production of volatile fatty acids (VFAs) that are the precursors of biogas. It increases digester capacity and efficiency by reducing the retention time and providing optimum conditions to maximize the hydrolysis rate, which is the rate-limiting step of anaerobic digestion.

Acid/gas phased digestion is a type of biological hydrolysis that consists of a highly loaded “acid-phase” digester followed by a lightly loaded “gas-phase” digester. This process is purported to improve volatile solids (VS) destruction and mitigate foaming. There is also literature suggesting that operation of acid phase digestion with HRTs/SRTs greater than1.7 days has also been shown to worsen foaming in the downstream methane phase.

Enzymic hydrolysis is another type of biological hydrolysis that uses six smaller reactors in series to hydrolyze sludge at 107 °F for 2 days. An enhanced version of this process operates the last two reactors at 145 °F to achieve Class A biosolids (Barber et al., 2019).

B-3. Chemical/Thermal Hydrolysis

Classification: Pre-Treatment.

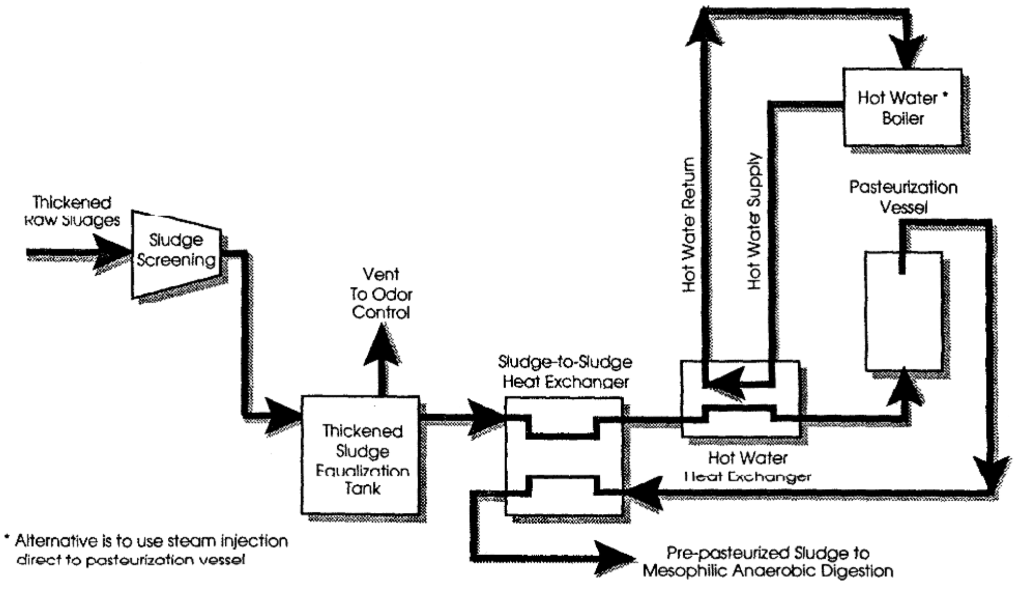
Description: See Section B-32 for the description of Lystek as an example of Chemical/Thermal Hydrolysis.

B-4. Pre-Pasteurization

Classification: Pre-Treatment.

Description: In the pre-pasteurization process, raw sludge is heated to temperatures high enough, and for long enough, to satisfy Class A pathogen reduction requirements. This process can be done using batch vessels and possibly by continuous flow systems. Batch operations are preferred by EPA as they ensure that Part 503 minimum contact times are met by each sludge particle, despite their added additional mechanical complexity. Typically, pre-pasteurization is used upstream of conventional anaerobic digestion but has some potential applications with aerobic digestion as well. Heating can be achieved using direct steam injection, hot water heat exchangers, and submerged combustion. Pre-pasteurization can also be conducted through an aerobic thermophilic process (see ATAD or ATP).

BC would caution against using sludge-to-sludge heat exchangers (as shown in the flow sheet below) due to extensive problems experienced in attempts to keep such units in service. We have had better experience with sludge-to-water-to-sludge systems; but such systems are of greater effectiveness in larger plants with higher sustained sludge flows of 250 to 300 gpm or higher (Shafer et al., 1994).



Simplified Pre-Pasteurization Flow Diagram – Heat Only

B-5. Aerobic Thermophilic Pretreatment (ATP)

Classification: Pre-Treatment.

Description: Aerobic Thermophilic Pretreatment (ATP) is a highly effective biosolids stabilization technology where biosolids are subjected to aerobic digestion at elevated temperatures, typically ranging from 50°C to 70°C. In this process, biosolids are maintained at thermophilic temperatures, which accelerates microbial activity and the presence of oxygen promotes aerobic bacteria growth. This aerobic process is auto thermal, meaning that it self-heats and can achieve operation at near 65°C without external heating. The combination of elevated temperature and aerobic conditions effectively reduces pathogens (such as harmful bacteria and viruses) present in the biosolids, making the material safer for subsequent use or disposal. Additionally, ATP promotes the volatilization of volatile solids, leading to a reduction in the biosolids' mass. The resulting pasteurized biosolids (Class A biosolids) meet stringent regulatory standards and can be safely utilized for land application, composting, or other beneficial purposes.

The Aerobic Thermophilic (AT) reactor is a complete mix vessel that works in batches to ensure pathogen destruction and avoid short circuiting. A portion of the treated sludge is removed, typically daily, and replaced with untreated sludge. Sludge-to-sludge heat exchangers are used to reduce temperature of the sludge to mesophilic range and to preheat raw sludge for the AT reactor. Few plants operate on High Purity Oxygen (HPO) (Shafer et al., 1994).

B-6. Intermediate Thermal Hydrolysis

Classification: Pre-Treatment.

Description: The intermediate thermal hydrolysis process (ITHP) is a two-stage digestion method designed to enhance biogas production from sewage sludge. It involves a thermal hydrolysis unit placed between two anaerobic digesters. The process starts with the first digester treating thickened sludge, which is then (possibly dewatered and then) subjected to thermal hydrolysis before entering the second digestion stage. This approach targets the more recalcitrant compounds, leading to increased volatile solid removal and biogas generation. ITHP offers the benefit of reducing the volume of sludge requiring hydrolysis and thus saving on capital costs for hydrolysis reactors and boilers. The process has been implemented in several plants across Europe, demonstrating its viability and efficiency in sludge management and energy recovery (García-Cascallana et al., 2021).

B-7. Pulsed Electric Hydrolysis

Classification: Pre-Treatment.

Description: Pulsed Electric Hydrolysis (PEH) or Pulsed Electric Field (PEF) technology is an emerging biosolids stabilization technology for wastewater treatment. PEH leverages pulsed electric fields to enhance the valorization of wastewater treatment residuals, including sewage sludge. One of its key features is cell disintegration, achieved by its purported breaking down cell structures and improving cell membrane permeability. This makes PEH suitable for applications such as disinfection, sterilization, and extraction of organic compounds from biological matter. PEH has implications for various processes, including anaerobic digestion, nutrient recovery, and biorefinery of cell-embedded compounds. By enhancing the extraction of organic compounds, it could contribute to improved digestion effectiveness and potentially improved dewatering (Capodaglio, 2021).

BC does not have experience with this process. We have reservations about its effectiveness and would encourage additional testing prior to its integration in any full scale upgrades.

B-8. Solid Stream Thermal Hydrolysis

Classification: Pre-Treatment.

Description: Solid stream thermal hydrolysis is a biosolids dewatering-improvement process that has gained attention for its potential efficiency gains in specific sludge disposition settings. Traditionally, thermal hydrolysis was used as a pre-treatment step before anaerobic digestion, aiming to increase digester loading rates and improve dewatering.

In the solid stream process, thermal hydrolysis occurs after anaerobic digestion. The digested sludge undergoes thermal hydrolysis, resulting in hot dewatering. Additionally, the centrate (liquid portion) high in biodegradable chemical oxygen demand (COD) is recycled back to the digester. This approach not only enhances dewatering but also contributes to energy recovery and overall sludge management efficiency. The representative technology for this process is Cambi's SolidStream®. Although SolidStream® has demonstrated success in European plants that feed the treated solids to incineration or some other process to destroy the finished solids. Aligning it with the US EPA's Class A requirements under 503 regulations remains a challenge because the pathogen inactivation (Cambi) occurs downstream of the vector-attraction reduction step (anaerobic digestion) (*Cambi Solidstream: Thermal Hydrolysis as a Pre-Treatment for Dewatering - Cambi*, n.d.).

B-9. Thermal Hydrolysis (No Steam)

Classification: Pre-Treatment.

Description: Continuous Thermal Hydrolysis is a biosolids stabilization process that operates without the need for steam or pre-treatment chemicals. Instead, it employs a series of heat exchangers to create closed loops for thermal oil and water. These heat exchangers ensure an optimum heat balance while exposing the sludge to controlled temperature and pressure. By disintegrating the sludge particles, Continuous Thermal Hydrolysis makes the solids more readily biodegradable. Notably, this process increases gas production, improves volatile solids destruction, enhances dewaterability of solids, and operates without the use of steam. A representative technology for thermal hydrolysis is the Ovivo LysoTherm system (LysoTherm - Ovivo Water, n.d.).

BC is reluctant to recommend this due to concerns with heat exchanger fouling. Such challenges have been apparent:

- In conventional digestion when the heating loop is run too hot; that would be a necessity in this process as described.
- In hydrothermal liquefaction (HTL) research where similar heat exchangers in series could not be maintained in service due to fouling-induced pressure increases/failures. To the point that current HTL thinking has migrated toward steam-heated preliminarily heating (to 150 or 200°C) like that used in thermal hydrolysis.

B-10. Conventional (Mesophilic) Anaerobic Digestion (MAD)

Classification: Anaerobic Digestion.

Description: Mesophilic anaerobic digestion (MAD) is a conventional sludge stabilization process. MAD typically employs operating temperatures between 95 and 102 °F and solids are digested under anaerobic conditions. Typically, MAD systems are operated at a minimum hydraulic retention time (HRT) of 15 days, which, when requirements for vector attraction reduction are met, guarantees Class B pathogen status for beneficial use. This stabilization process has the longest operational history of the processes under consideration.

Although this alternative provides the benefits of operational simplicity and a long history of operation, the process has its disadvantages when compared to newer, more aggressive technologies. While MAD operates efficiently, the degradation rates are relatively low when compared with other advanced digestion processes. This lower biological degradation rate results in lower VS destruction, lower gas production, more tankage volume required, and additional mass of solids for disposal relative to the advanced digestion processes evaluated. In addition, use of MAD allows for less available capacity for co-digestion substrates because of the inherently lower organic loading rate (OLR) associated with the process. The table below summarizes the advantages and disadvantages of MAD (Labatut et al., 2014).

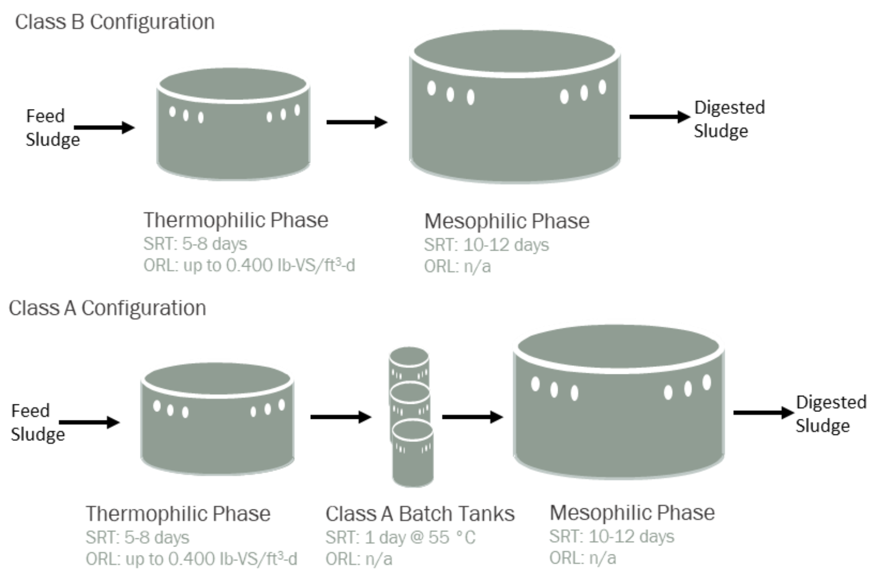
Mesophilic Anaerobic Digestion Considerations and Typical Operational Parameters		
Advantages	**Disadvantages**	
• Existing familiarity • Operational simplicity • Can be paired with other processes • Low operating temperatures • Long history of operation	• Potential for struvite scaling • Lower volatile solids destruction • Lower gas production • Greater capacity required • Greater mass of solids remaining • Less flexibility for additional co-digestion • Digester gas entrainment requires careful monitoring	
Operational temperature range	**Minimum Hydraulic Retention Time**	**Max Volatile Solids Loading Capacity**
95 to 102°F	15 days	0.15 lb-VS/ft^3-d

B-11. Temperature Phased Anaerobic Digestion (TPAD)

Classification: Anaerobic Digestion.

Description: A temperature-phased anaerobic digestion (TPAD) system operates in two distinct temperature phases, digesting sludge in different tanks arranged in series. The first phase is the thermophilic phase, which typically operates at a hydraulic retention time (HRT) of between 5 and 10 days. This is followed by a mesophilic phase typically operated between 6 and 15 days HRT. If Class B biosolids are desired, the TPAD system would be designed such that the combined retention time meets the 15-day HRT requirement. The high loading rate can allow for smaller digesters, reducing footprint relative to the overall system capacity, if the relevant criterion for total system HRT is met.

By phasing the digestion process through the thermophilic phase to the mesophilic phase, the advantages of thermophilic digestion are gained but carry an additional benefit of allowing the mesophilic phase to “polish” the volatile acid concentrations, improve VSR, and reduce product odors. The thermophilic digestion phase is typically characterized by high biogas production rates, high VS destruction (60 to 65 percent), and enhanced pathogen kill. Most of the stabilization occurs in the thermophilic phase. Due to the higher OLR and temperature in the thermophilic phase, there are higher volatile acid and ammonia concentrations. When cooled and allowed to enter the mesophilic phase, these concentrations are polished, decreasing volatilized ammonia and other odorous compounds. Like TAD, TPAD can be configured to generate Class A biosolids (US EPA, 2006b).



Process schematic of temperature-phased anaerobic digestion

Temperature-phased Anaerobic Digestion Considerations and Typical Operational Parameters

Advantages	Disadvantages
• Quick recovery following contamination event • Potential for maximum gas recovery and biosolids quality • Higher OLR/capacity • Improved dewatering • Improved pathogen destruction • Potential for Class A biosolids (with batch tanks)	• Higher heat demand • Requires changes to plant heating, gas treatment, and/or structural upgrades • Increase in O&M • Potential increase in polymer demand • Requires additional cooling system between two stages, which increases process complexity • Requires additional tankage relative to other processes

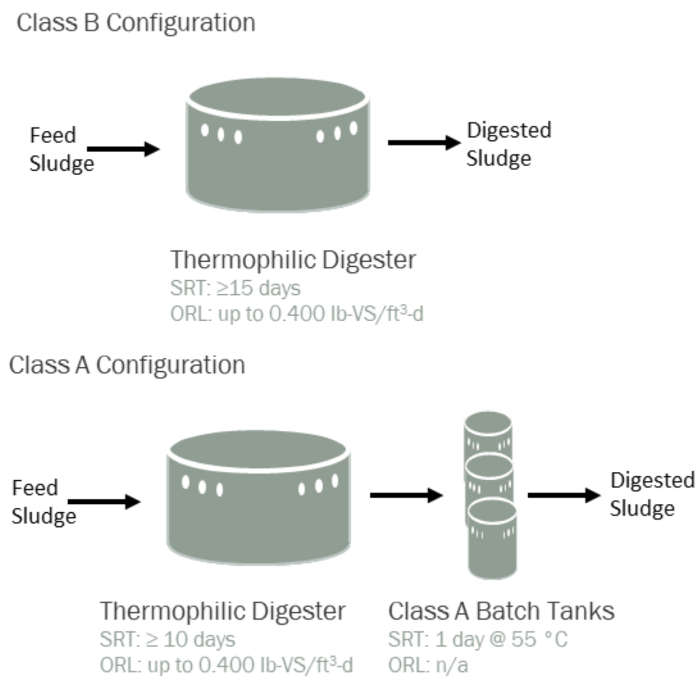
Operational temperature	Hydraulic Retention Time	Max Volatile Solids Loading Capacity
95 to 102°F 122 to 132°F	15 days total for Class B Additional 1-day batch hold for Class A (at thermophilic temperatures)	0.35 lb-VS/ft³-d

B-12. Thermophilic Anaerobic Digestion

Classification: Anaerobic Digestion.

Description: Thermophilic anaerobic digestion (TAD) is a means of enhancing digestion capacity through anaerobic digestion at thermophilic temperatures, typically ranging from 122 to 132°F. The high-temperature operation increases reaction rates and increases gas production, solids destruction, and pathogen inactivation. TAD can accommodate approximately double the OLR of MAD, up to 0.4-pound VS per cubic foot per day (lb-VS/ft^3-d).

Thermophilic digestion can be configured to generate Class A biosolids. This can be accomplished with batch tanks, for example, where the sludge is held for 24 hours at thermophilic temperatures (131°F or greater) to meet EPA requirements for Class A. Some wastewater treatment facilities, like the City of Los Angeles, have produced Class A biosolids using thermophilic digestion with limited-size batch tanks, which results in somewhat less time and temperature stipulated by the Class A criteria; however, additional sampling and testing of the biosolids is required to demonstrate Class A compliance in such instances (Labatut et al., 2014).



Process Schematic of Class A and Class B Thermophilic Digestion

Thermophilic Anaerobic Digestion Considerations and Typical Operational Parameters		
Advantages		**Disadvantages**
• Increased organic loading • Increased solids destruction capability • Improved dewatering • Increased gas production • Increased pathogen destruction • Potential for Class A biosolids • Fewer gas entrainment issues compared to MAD • Proven technology • Accommodates co-digestion better than MAD		• Higher heat demand • Potential for increased odor in final product and in dewatering facilities • Requires changes to plant heating, gas treatment, and/or structural upgrades (where applicable) • Increased polymer demand
Operational temperature	**Minimum Hydraulic Retention Time**	**Max Volatile Solids Loading Capacity**
122 to 132°F	15 days	0.35 lb-VS/ft^3-d

B-13. MAD + Post Aerobic Digestion

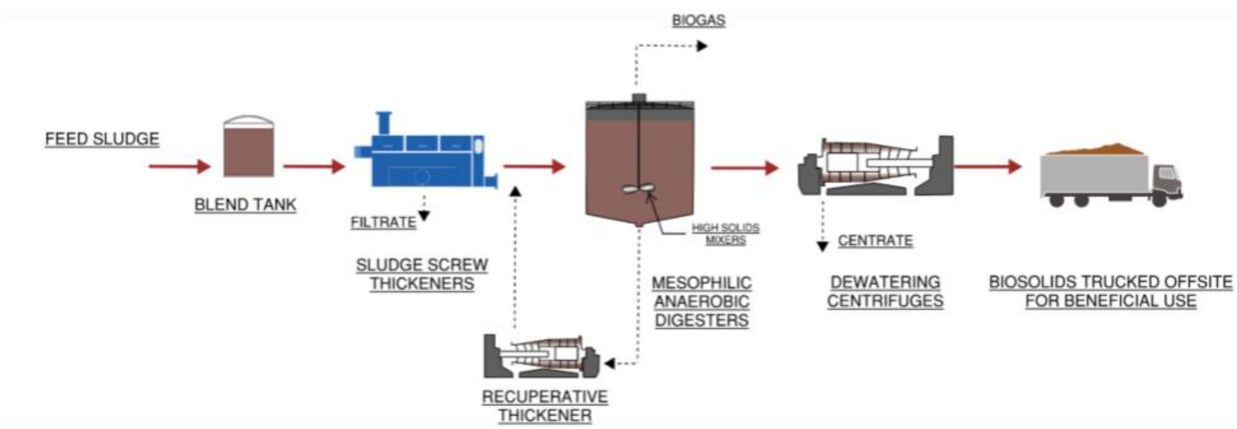
Classification: Anaerobic Digestion.

Description: Mesophilic Anaerobic Digestion (MAD) followed by Post-Aerobic Digestion is an effective process for stabilizing biosolids. During MAD, organic matter in biosolids breaks down in a moderate-temperature anaerobic environment, producing biogas. After anaerobic digestion, the solids stream (anaerobic digester effluent) enters the Post-Aerobic Digestion system which exposes the biosolids to oxygen, further stabilizing them and reducing volatile solids. Residual organic compounds serve as a carbon source for denitrification during PAD. PAD improves dewaterability of sludge and changes the odor profile of the digested sludge to be less offensive (McNamara et al., 2022).

B-14. Recuperative Thickening

Classification: Anaerobic Digestion.

Description: Recuperative thickening consists of a dedicated thickener installed on a dedicated recirculation loop for a digester. Digested solids are withdrawn from the digester, thickened, and thickened solids are returned to the digester. Pre-thickening the digester feed reduces digester heat demand but may not achieve the same solids concentration in the digester as a recuperative thickening system. Recuperative thickening can achieve a higher solids concentration in the digester compared to pre-thickening, but requires additional mechanical equipment, increases polymer demand, and produces an additional thickening side stream. Both approaches can reduce the required anaerobic digestion tank volume, provided sufficient mixing energy is provided in the digester tank. Proprietary propeller mixers have been successful when operated at digested solids concentrations above 3.5 percent TS (Oleszkiewicz & Mavinic, 2002).



High-Solids Digestion Using Recuperative Thickening

B-15. High Solids Digestion

Classification: Anaerobic Digestion.

Description: High-solids anaerobic digestion (HS-AD) involves operating anaerobic digesters at solids concentrations higher than traditional methods. For high-solids digestion the solids feed is greater than 9% total solids (TS). HS-AD can be used to conserve footprint at an existing facility or can be used to process dewatered wastewater and other organic waste such as food waste and fats, oils, and grease. A few technologies such as Omnivore® by Anaergia and Komogas are high solids continuously stirred reactors with installations in the USA. HS-AD can optimize existing infrastructure, reduce footprint requirements, and reduce heat demands but may result in challenging and/or unique materials handling requirements for a facility that chooses to implement it, depending on the material being digested (High Solids Anaerobic Digestion, 2024), (*What We Do - How We Create Good Things from Organic Waste*, 2020).

B-16. Conventional Aerobic Digestion

Classification: Aerobic Digestion.

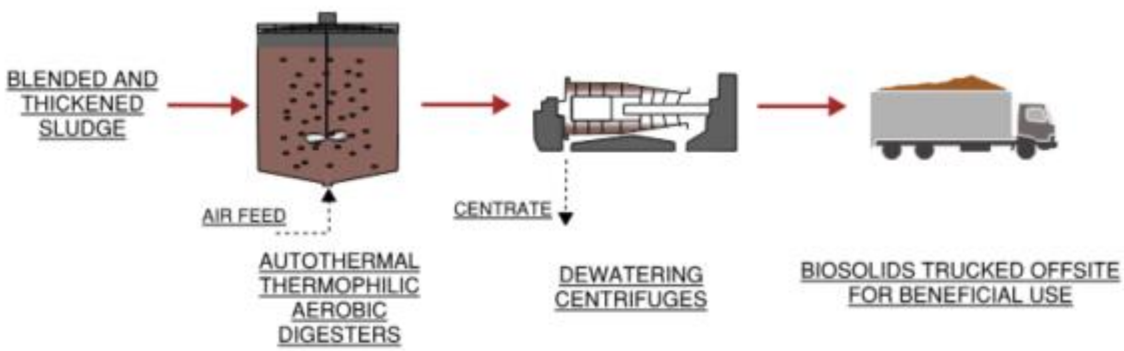
Description: Aerobic digestion is a biological process similar to anaerobic digestion, but where microorganisms consume oxygen. The aerobic bacteria stabilize and reduce the mass of volatile material in the solids, converting them into carbon dioxide, water, and other minor constituents. The aerobic process is similar to the activated sludge process: oxygen must be provided to maintain the process (either as air or high-purity oxygen) and microorganisms will consume available degradable organic material before consuming themselves as the availability of external substrates is depleted (i.e., endogenous respiration). Unlike anaerobic digestion, aerobic digestion does not require an external source of heat. In fact, a type of aerobic digestion (autothermal thermophilic aerobic digestion [ATAD]) utilizes the heat released from the exothermic oxidation process to maintain thermophilic temperatures in the digester. The ATAD process also occurs in a shorter time frame (five to 10 days of retention time) allowing for smaller tanks and reduced capital cost. The aerobic digestion process can produce either Class A or Class B biosolids that are stable and suitable for beneficial land application; however, biogas is not produced in the process and aeration of the tanks requires significant amounts of energy to supply the required oxygen. Aerobic digestion can be coupled with anaerobic digestion to take advantage of the benefits from the two systems. Aerobic digestion can be used as a pre-processing step to an anaerobic process or as a post-anaerobic digestion step to enhance volatile solids destruction. The City of Tacoma uses an ATAD system ahead of a temperature-phased anaerobic digestion (TPAD) system at its Central Treatment Plant in Tacoma, Washington. This combination produces Class A biosolids and minimizes odors (LLaurado, 2008).

Aerobic Digestion Considerations	
Advantages	**Disadvantages**
• Simple technology • Relatively low cost • Reliable stabilization • Can produce Class A biosolids	• High energy consumption • Does not produce biogas • Alkalinity depletion • Poor pathogen reduction • Impacts dewaterability • Large footprint required • Increased truck traffic

B-17. Auto-Thermophilic Aerobic Digestion (ATAD)

Classification: Aerobic Digestion.

Description: Autothermal thermophilic aerobic digestion (ATAD) is an aerobic digestion process that is operated at thermophilic temperatures to achieve solids stabilization and pathogen reduction. The process is operated at thermophilic temperature of 110 °F to 150 °F. The temperature is achieved by using the exothermic microbial oxidation process. With sufficient insulation, appropriate hydraulic retention time (HRT), adequate solids concentration, and mixing, the process can be controlled to maintain thermophilic temperatures and achieve high volatile solids destruction. When controlled to a temperature between 122 and 140 °F and maintained for a 10day SRT, the process meets U.S EPA 40 CFR Part 503 Class A designation (Pembroke & Ryan, 2019).



Autothermal Thermophilic Aerobic Digestion Process Flow Diagram

B-18. Aerobic/Anoxic Digestion

Classification: Aerobic Digestion.

Description: Aerobic/Anoxic digestion is a type of sludge stabilization process that alternates between aerobic and anoxic conditions to reduce organic matter, nitrogen, and pathogens in wastewater sludge. Aerobic/Anoxic digestion will decrease the supernatant nitrogen concentration in the biosolids. During the aerobic phase, microorganisms thrive in the presence of oxygen and break down organic matter. The end products are carbon dioxide and water. During the anoxic phase, there is no molecular oxygen. Instead, the environmental may contain nitrates or nitrites and the microorganisms use them as the alternative electron acceptors. The result is the production of nitrogen gas and other compounds (Abbott et al., 2021).

B-19. Windrow

Classification: Composting.

Description: In windrow composting, dewatered wastewater solids are mixed with bulking agents and arranged in long rows or “windrows”. The piles are mechanically turned using operator-driven equipment to provide aeration. This periodic mixing is essential to provide oxygen to the microbes and move material on the outer surface inward, which subjects all the material to the higher temperatures deeper in the pile. A number of turning devices are available, including drums and belts powered by agricultural equipment and are pushed or pulled through the composting pile, and self-propelled vehicles that straddle the composting pile. As with aerated static-pile composting, the material is moved into bulk curing piles after active composting. Windrow composting can typically take 3 to 6 months to compost and an additional 1 to 3 months to cure (Michel, O’Neill, Rynk, Gilbert, et al., 2022).

Picture of windrow composting
Source: U.S. Composting Council

Windrow Composting Considerations and Typical Operational Parameters		
Advantages	**Disadvantages**	
• Low tech and capital investment • Simple operation and maintenance • Low energy use • Produces Class A biosolids	• Large footprint-to-capacity ratio • Requires large volume of bulking agent • Labor intensive • Limited process control • Exposed to the environment • Slow active composting phase • No odor control possible	
Composting Period	**Curing Time**	**Aeration Type**
3 to 6 months	1 to 3 months	Manual agitation

B-20. Enclosed/In-Vessel

Classification: Composting.

Description: In-vessel composting occurs within an enclosed vessel, which enables an operator to maintain precise control over the process in comparison with other composting methods. A mixture of dewatered cake and bulking agent is fed into a silo, tunnel, channel, or vessel. Augers, conveyors, rams, or other devices are used to aerate, mix, and move the product through the vessel to the discharge point. Air is generally blown into the mixture. After the active composting phase, the compost is cured in bulk piles prior to distribution. There are several types of in-vessel composting reactors, including vertical plug-flow, horizontal plug-flow, and agitated bin. For raw solids composting, in-vessel technology is more suitable than other composting technologies in suburban and urban settings because of the system's ability to contain and treat odors as well as its high throughput capabilities (Michel, O'Neill, Rynk, Bryant-Brown, et al., 2022).

Enclosed/In-vessel composting

Source: Hot Rot

Enclosed/In-vessel Composting Considerations and Typical Operational Parameters		
Advantages		**Disadvantages**
• High-tech composting solution • Large solids capacity • High process control and flexibility • Decreased risk of anaerobic condition • Limited impacts from environmental factors • High-rate process • Limited odor risk • Produces Class A biosolids		• More complex operations and equipment • More equipment and assets to manage • Requires odor control • High energy consumption • Requires large footprint
Composting Period	**Curing Time**	**Aeration Type**
2 to 6 weeks	More than 1 month	Forced aeration + other

B-21. Aerated Static Pile

Classification: Composting.

Description: In aerated static composting, dewatered cake is mechanically mixed with bulking agents and stacked into long piles over a bed of perforated pipes through which force air is applied to the compost material. The forced aeration accelerates the biological activity and removes moisture and heat to prevent inhibition of the process. After the active composting phase, as the pile starts to cool down, the material is moved into a curing pile (*Approaches to Composting*, 2023).

Aerated Static Pile Composting

Source: Sustainable Generation and Gore

Aerated Static Pile Composting Considerations and Typical Operational Parameters		
Advantages	**Disadvantages**	
• Large solids capacity • High process control and flexibility • Decreased risk of anaerobic conditions • Minimally impacted by environmental factors • Minimally dependent on mechanical equipment • High-rate process • Lower odor risk	• More equipment and assets to manage • Requires some odor control • Higher energy consumption • Requires large footprint • Requires large volume of bulking agent	
Composting Period	**Curing Time**	**Aeration Type**
2 to 6 weeks	More than 1 month	Forced aeration

B-22. Membrane Covered Pile

Classification: Composting.

Description: Membrane covered pile composting is more sophisticated than aerated static pile and is relatively newer. In this configuration, piles are covered with a membrane that traps moisture and odors but allows oxygen and carbon dioxide transfer. Aeration is provided via an aerated floor, and sensors are used to control aeration. There is a 28-day initial composting period followed by 14-day secondary composting period, both covered. The process is finished with a final 14-day period of aerated composting without a cover. This process claims reduced odors compared to other methods (Fang et al., 2022).

B-23. Direct Thermal Drying

Classification: Drying.

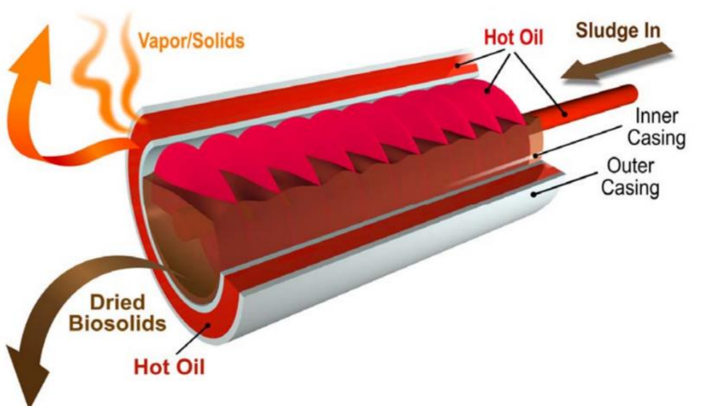
Description: Direct Drum dryers is a direct drying process that mixes heated air with biosolids. The heated air comes in contact with the biosolids in a rotating drum, evaporates water from the biosolids, and produces a granule. Drying begins when dewatered sludge is mixed with the recycled solids to control the moisture content of the mixture and minimize sticking to the inner surface of the drum and to allow the wetter sludge to absorb the finer solids coming from the crusher. Air heated to between 850°F and 950°F is introduced in the drum while the sludge mixture tumbles through and exits the other end. From the dryer, the dried solids are fed to a separator to separate the hot air from the solids. The solids are then screened; particles of the appropriate size are conveyed to storage silos while other solids are sent to a crusher. Crushed biosolids are blended with fresh dewatered sludge as described previously. Air emission and odor control systems consist of polycyclones, impingement trays, condensers/sub-coolers, venturi scrubbers, and regenerative thermal oxidizers for the process of off-gas emission control. Up to 75 percent of exhaust gas recirculation is applied to increase the efficiency of the drying system and reduce total dryer system air emissions and odor potential (US EPA, 2006a).

<table>
<tr><th colspan="3">Direct Drum Drying Considerations and Typical Operational Parameters</th></tr>
<tr><th colspan="2">Advantages</th><th>Disadvantages</th></tr>
<tr><td colspan="2">Creates dense, uniform pellets that are highly marketable
Proven operational history</td><td>Highest level of O&M risk
Large footprint
Requires large number of ancillary systems
High repair and replacement costs
Inflexible with alternative heat sources</td></tr>
<tr><th>Heating Medium</th><th>Temperature</th><th>Product Quality</th></tr>
<tr><td>Air</td><td>1,100°F</td><td>Dense pellet, 2 to 4 mm</td></tr>
</table>

B-24. Indirect Thermal Drying

Classification: Drying.

Description: Indirect drying systems are called such because the heating source does not come into direct contact with the solids, as it does in direct drying systems. Instead, indirect drying systems use steam or thermal oil as a heating medium that indirectly heat wastewater solids across a conductive boundary. Indirect dryers include fluidized bed, paddle, rotary screw, tray, and others. The typical heat-dried product is at least 90 percent solids, which means the volume and mass of hauled solids is significantly less than many other solids stabilization processes; however, solids drying is typically employed for digested solids. Raw solids drying is possible but is not generally recommended by dryer manufacturers. In particular, drying primary sludge solids can create significant odors, and the high volatile content of raw solids can increase the risk of fires. There are a number of indirect dryer manufacturers. While some indirect drying technologies can produce Class A biosolids, they yield a product with different physical characteristics from the drum dryer (US EPA, 2006a).



Schematic Diagram Of Indirect Dryer

Indirect Drying Considerations and Typical Operational Parameters		
Advantages		**Disadvantages**
• Small footprint required • Low exhaust volume • Uses thermal oil		• Causes reactor abrasion • Corrosion and thermal cycling • High dust level
Heating Medium	**Temperature**	**Product Quality**
Oil	430°F	Granule, 1 to 15 mm

B-25. Solar Drying

Classification: Drying.

Description: Solar drying uses radiant and convective heat transfer methods in a greenhouse system to dry the solids. The greenhouse system is typically constructed with multiple large bays that allow for isolating a bay once it is fully loaded or allows for continuous throughput through multiple bays. Dewatered solids are spread within a drying chamber, and various types of mixing systems are used to expose wetter material to the greenhouse atmosphere and move the material from one end of the bay to the other end. A microprocessor controls vents and fans to optimize the humidity level within the chamber to promote drying. Foul air/odor control is used for installations that are located close to sensitive development. Solar drying is typically used to dry to between 40 and 90 percent total solids (TS). The relatively higher TS concentrations require more time in the drying chamber and can create sufficient dust for safety concerns. Demonstrating compliance of solar drying with Class A criteria has been difficult and typically only occurs if the biosolids reach around 90 percent or more TS. The primary advantage of solar drying is the low energy needed to create a partially dried or largely dried biosolids product. The primary disadvantages of solar drying are that it requires significant site space and usually results in a large range of particle sizes which make product marketing and/or land application more challenging (Weinert & Grosser, 2012).

B-26. Vertical Tray Drying

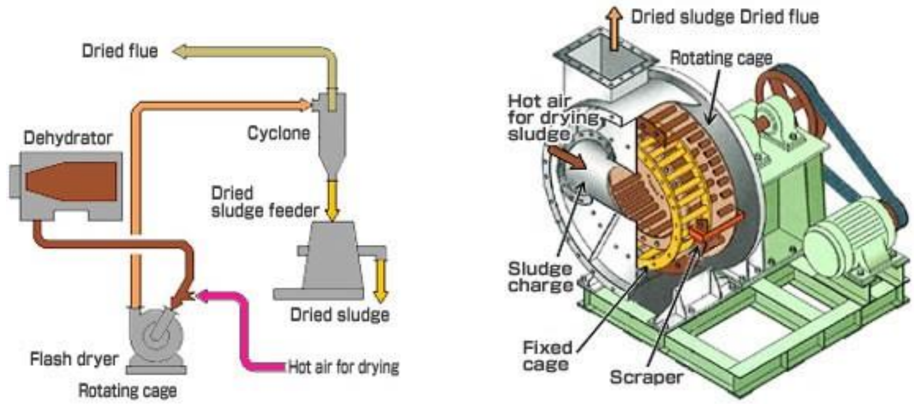
Classification: Drying.

Description: A vertical tray dryer is a type of indirect thermal drying. Dewatered solids enter the drying system and are placed on a rotating drying tray. The drying tray is used to evenly distribute solids and heat for consistent drying. The outer portion of drying tray slowly rotates around the center stack, which circulates heated air or gas to evaporate water from the solids. The system typically consist of multiple stacks where solids from top tray are dropped to the tray below for further processing and drying. Unlike some other drying methods, this process does not significantly alter the nutrient content of the biosolids. The Komoline-Wyssmont Turbo Dryer is an example of a vertical tray dryer that uses circular trays that, after they complete a revolution, wipe material to the next lower tray where the biosolids are mixed and leveled and then the operation is repeated. The system can range from evaporation capacities from 200 to 25,000 lbs per hour. Smaller systems can be supplied as package system (*Komoline-Wyssmont Turbo Dryer* , 2024).

B-27. Flash Drying

Classification: Drying.

Description: Flash dryers are a type of direct thermal drying where solids are essentially put on a hot pneumatic conveyor where they are rapidly dried. Flash drying machines, equipped with a sludge cracking function, break down large sludge particles using rotating and fixed cages. The key is the direct hot air, which rapidly evaporates moisture, creating a larger surface area for drying. Once the sludge passes through the flash dryer, it emerges as powdered-granulated dried sludge, and is typically collected by a cyclone separator (*Kawasaki Sludge Processing System*, 2022), (US EPA, 2006a).



Schematic and Drawing of Flash Drying
Source: Kawasaki Sludge Processing System

B-28. Fluidized Bed Drying

Classification: Drying.
Description: Fluidized bed drying is a technology that uses hot air or gases to dry and process wastewater solids. It consists of a vertical, refractory-lined, steel shell cylinder with a layer of inert sand at the bottom. The sand is kept in a fluid state by an upflow of air through a perforated plate that sits below the sand and serves as a heat reservoir to promote uniform drying. Solids are fed into the sand bed, where they mix with the heated sand and evaporate their moisture. The dried solids and water vapor are carried out through the top of the furnace, and the solids are separated from the gas by a cyclone or a scrubber. Fluidized bed dryers require operation with back mixing of part of the dried sludge product stream with the feed to prevent the sludge going through the sticky phase (US EPA, 2003).

Indirect Drying Considerations and Typical Operational Parameters	
Advantages	**Disadvantages**
• High thermal efficiency and low fuel consumption. • Short drying time and low solids retention time. • Ability to handle variable feed rates and moisture contents. • Low emissions of nitrogen oxides, carbon monoxide, and hydrocarbons. • Reduced maintenance and operational problems.	• High capital investment and operating costs5. • Complex solids feed and handling systems. • Potential for dust explosion and fire hazards. • Need for air pollution control equipment to meet regulatory standards

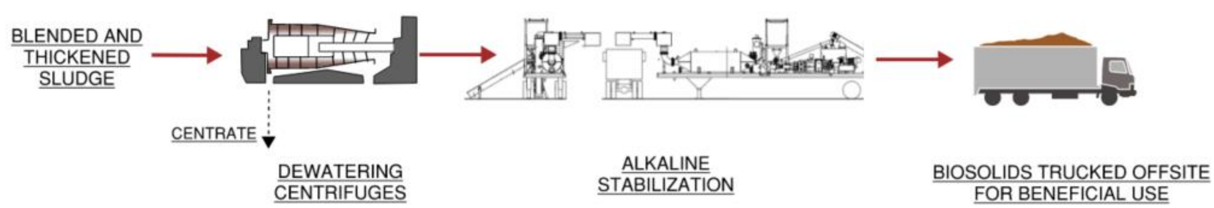
B-29. Alkaline Stabilization

Classification: Chemical Stabilization.

Description: Alkaline stabilization is the process of adding alkaline chemicals to organic materials to increase pH and reduce pathogens. Hydrated lime and quicklime are most often used, although other chemicals are available. Either Class B or Class A biosolids can be achieved with this method. The short reaction time and exothermic reaction of adding quicklime to a wet product results in shorter detention times and less heating than is required for anaerobic digestion. This can lead to lower initial capital cost.

This process does not result in any biomass reduction. In fact, the chemical addition increases the overall mass of the resulting biosolids. In addition, annual costs are typically higher for alkaline stabilization systems when compared to anaerobic digestion due to chemical and biosolids hauling costs.

The stabilized product can be used for a variety of end uses such as landscaping, agriculture, mine reclamation, and landfill cover. Depending on the soil to which the product is applied, the final product can be more favorable for some vegetation as it can improve soil pH due to the added alkaline chemicals. However, extensive odor control may be required to treat ammonia and other off gases. If not designed and operated properly, alkaline treatment systems can be dangerous to operators, create noxious fumes, and/or fail to achieve the necessary pathogen reduction required for Class B or Class A biosolids (US EPA, 2018).

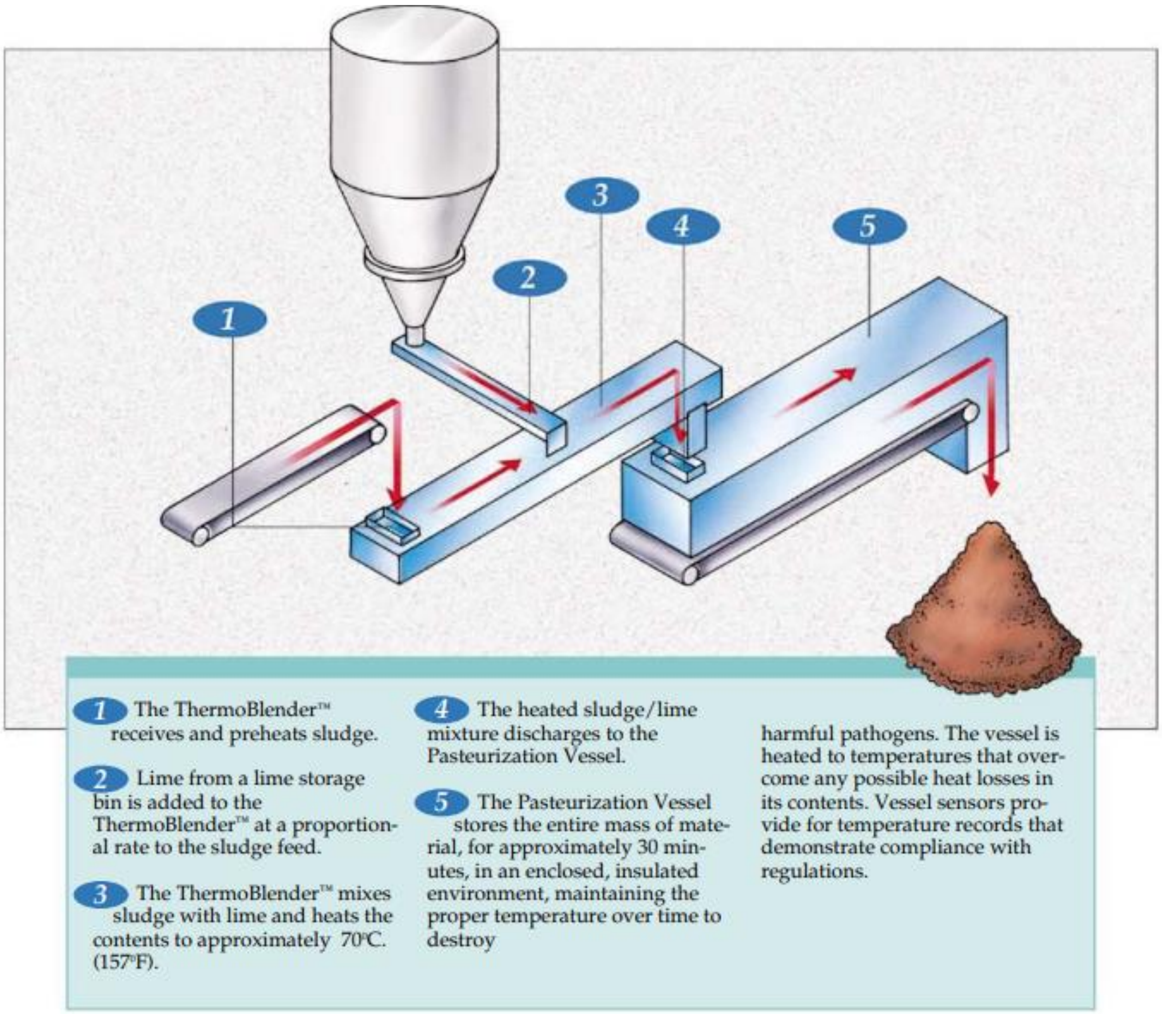


Process Flow Diagram for Alkaline Stabilization

B-30. EnVessel Pasteurization

Classification: Chemical Stabilization.

Description: EnVessel Pasteurization is a patented process that pasteurizes and produces sludge that is pathogen free and ideal for land and agricultural application. The process uses time, temperature, and high pH to destroy harmful pathogens, and relies on supplemental heat to reduce the amount of lime required and the operating costs. The process also guarantees that the end product will meet US EPA criteria for Class A pathogen reduction and vector attraction reduction levels. EnVessel Pasteurization is designed and manufactured by RDP Technologies, Inc., which has over 15 years of experience in sludge/lime mixing equipment and controls. This technology is a type of Alkaline Stabilization that uses electric energy to generate heat in addition to lime. Class-A pathogen treatment is achieved by compliance with Alternative 1 (time and temperature) whereas vector attraction is achieved by the product's high pH. The process increases the overall dry solids in the product, can be a source of odors, but can be attractive for alkalinity-poor soils (EnVessel Pasteurization, 2023).



Flow sheet for EnVessel Pasteurization
Source: RDP Technologies

B-31. Schwing Bioset

Classification: Chemical Stabilization.

Description: The primary aspect of the Bioset process lies in Schwing Bioset's piston pump technology, which has been successfully used in wastewater applications for over three decades. The process involves blending biosolids with quicklime and sulfamic acid. This combination meets both the temperature and pH requirements specified by the USEPA's 503 regulations to produce Class A biosolids and make Schwing Bioset one of the few processes that received Class A Equivalency from the EPA. The resulting product is homogenously mixed and suitable for long-term storage, making it ideal for cold-weather climates. The process is continuous, with reactor retention time controlled by flow rate and temperature monitored through probes. Enclosed to control dust and odors, the end product is highly suitable for land application or landfill cover.

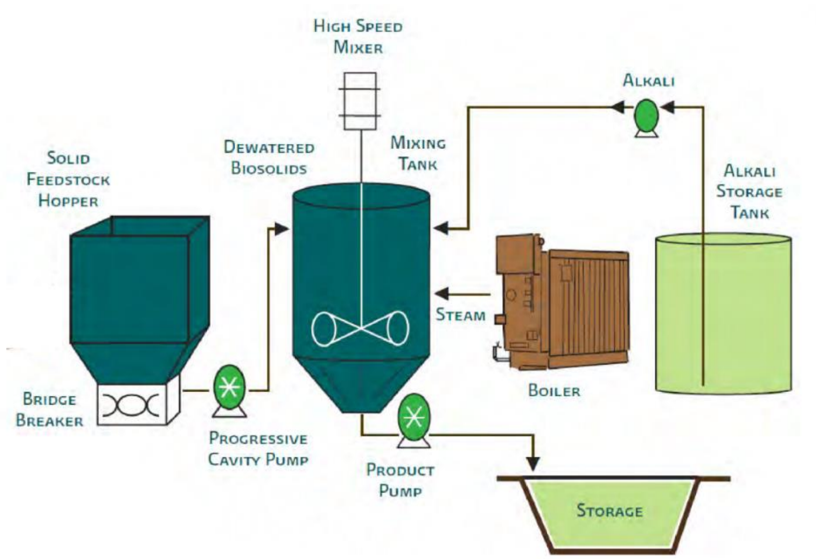
Much like EnVessel Pasteurization, Class-A pathogen treatment is achieved by compliance with Alternative 1 (time and temperature) while vector attraction reduction is achieved by the product's high pH. The process increases the overall dry solids in the product, can be a source of odors, but can also be attractive for acidic soils (*Bioset Process*, n.d.).

B-32. Lystek

Classification: Chemical Stabilization.

Description: The Lystek™ thermo-alkaline processing technology is a proprietary technology usually paired with digestion in either a pre- or post-anaerobic digestion configuration. The process includes a combination of high-speed shearing, alkali addition (process pH of 9.5 to 10.0), and low-pressure steam injection (process temperatures of 158°F to 167°F). This process changes the sludge rheology, which allows solids to be fed to digestion at 13 to 16 percent TS, which, when used in a pre-digestion configuration, can significantly decrease digester capacity requirements. Additionally, there have been reported increases in biogas production following the installation of Lystek™ systems. Lystek™ produces a liquid Class A biosolids product.

Lystek™ has five U.S. installations and 10 Canadian installations; it entered the U.S. market in 2016 with the 150,000-ton Organic Material Recovery Center located in the Fairfield-Suisun Sewer District in California. This complex, like many Lystek™ installations, serves as a regional biosolids processing facility, receiving biosolids from other plants in the area (e.g., San Francisco). The ability of this process to receive dewatered cake, like Cambi™ THP, lends itself to regionalization (*Lystek - Our Technology*, 2024).



Lystek™ thermo-alkaline hydrolysis process
Source: Lystek.com

Thermo-Alkaline Hydrolysis Process Considerations and Typical Operating Parameters	
Advantages	**Disadvantages**
• Potential to produce Class A biosolids • Supports regionalization • Potential to increase digester gas production • Product remains stable in long-term storage	• Requires additional mechanical equipment and asset investment • Hauling of high-solids liquid increases truck traffic and decreases the distribution radius • Liquid storage is required during winter months

B-33. BCR Neutralizer

Classification: Chemical Stabilization.

Description: The BCR Neutralizer system is a two-stage chemical treatment system that purportedly converts untreated biosolids into Class A/EQ residuals suitable for use as a commercial fertilizer. The system uses a patented chemical injection system to produce chlorine dioxide onsite and treat the biosolids with sodium chlorite, sulfuric acid, sodium nitrite, and sodium hydroxide. The system also enhances dewaterability, reduces polymer consumption, and removes phosphorus from the wastewater treatment facility. The BCR Neutralizer system is part of BCR's Whole Solution offering, which includes long-term responsibility for the transportation and end product management of the treated residuals. BC is not wholly convinced that the process meets all requirements for vector attraction reduction and Class-A biosolids treatment (and has seen examples of rampant vector regrowth in isolated quantities of treated material) (*BCR Solid Solutions - NEUTRALIZER*, 2021).

B-34. BCR Clean-B

Classification: Chemical Stabilization.

Description: The CleanB system is designed to treat Waste Activated Sludge (WAS) and various organic wastes directly on-site. It operates on a semi-continuous basis, producing Class B biosolids. CleanB employs chlorine dioxide as a powerful disinfectant. This step effectively eliminates harmful pathogens and reduces odors associated with sludge. By utilizing CleanB, facilities experience higher capture rates, reduced greenhouse gas emissions, and substantial cost savings. For instance, at the Fort Pierce wastewater treatment facility, CleanB significantly improved nutrient capture, reduced solids return, and lowered polymer consumption and can do so quickly (*BCR Solid Solutions - CleanB*, 2021).

B-35. Fluidized Bed Reactor Incinerator

Classification: High Temperature.

Description: Most recently installed incineration systems have been FBIs, which are more efficient, stable, and easier to operate than Multiple Hearth Furnace Incinerators (MHFIs). Like MHFIs, FBIs are vertically oriented, refractory-lined steel shell cylinders. The bottom level of an FBIs is an inert granular material, like sand, that is kept in a fluidized state during operation by an up flow of air. The sand bed acts as a heat reservoir to promote uniform combustion. Solids are fed into the preheated bed, where the solids and heated sand mix and the liquid is evaporated from the solids and volatile factor of the solids burn. Temperatures in FBIs are maintained between 1300-1600 °F. The combustion process occurs in the bed and in the freeboard area while the resulting ash and water vapor are carried out through the top of the furnace. Typically, a wet scrubber is used to remove ash from the exhaust gas where the ash is then transported offsite. Unlike in MHFIs, heat is captured from the FBI exhaust gas and recycled to maintain the required furnace temperatures, thus reducing, or removing the need for auxiliary fuel to be continuously supplied to the FBI (Van Caneghem et al., 2012).

B-36. Multiple Hearth Furnace Incineration

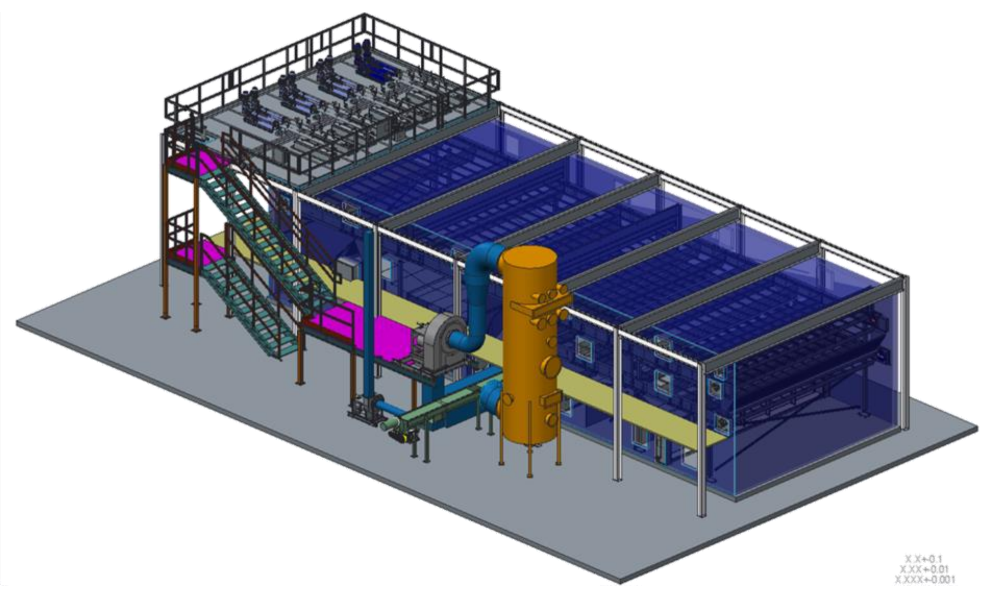
Classification: High Temperature.

Description: MHFI systems have historically been the most common technology used for wastewater solids incineration. The furnace consists of a cylindrical, refractory lined steel shell containing eleven stacked horizontal refractory hearths. There are three distinct operating zones: the drying zone, the combustion zone, and the cooling zone. Solids are fed into the top hearth and raked across each hearth. The solids drop down from one hearth level to the next. The solids burn a middle hearth, at temperature between 1400 and 1700 degrees Fahrenheit (°F). Discharged flue gas is sent through a scrubber to remove fly ash, acid gases. Ash removal is accomplished by rabble arms which push the hot ash on the lowest hearth through a drop out port. This ash is then conveyed to storage hoppers and transported offsite (US EPA, 2003).

B-37. Dryer/Furnace

Classification: High Temperature.

Description: High temperature drying is comprised of a drying cabinet, circulation fans, heat exchangers, heating system, condenser, and two stainless steel wire mesh belts. The sludge drying process employs indirect, convective heating to reduce sludge volume and produce a Class A biosolids product. The main piece of equipment that utilizes this technology is the BioCon™ Thermal Sludge Drying System by Veolia. In this process, biosolids are dried by extracting a portion of the air from the dryer, condensing it, and returning it to the system. The temperature decreases as the solids dry. The BioCon™ dryer does not utilize back-mixing which allows for a reduction of dust generated within the dryer building (<i>BioConTM Thermal Sludge Drying System</i>, 2024).



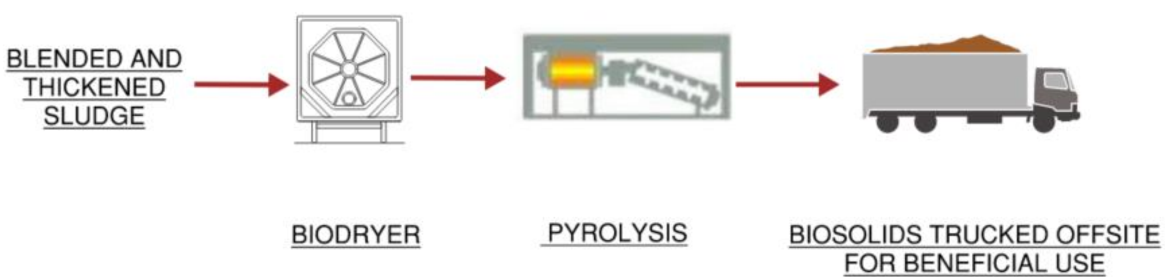
BioCon™ Thermal Sludge Drying System
Source: veoliawatertech.com

B-38. Pyrolysis

Classification: High Temperature.

Description: Pyrolysis is a thermochemical conversion process that is performed in the absence of oxygen. Pyrolysis systems tested to date with biosolids require drying of the solids prior to being introduced into the pyrolysis unit. The process converts the biosolids to biochar and syngas. Pyrolysis occurs at a range of high temperature typically between 570°F - 1,560°F. The syngas is a low-grade energy source with a heat value that ranges usually between 350 and 600 Btu per standard cubic foot and is composed of a mixture of primarily CH_4, CO_2, and hydrogen, along with other gases. The biochar has the capability to be sold as a slow-release fertilizer. However, the market is currently not well established.

Pyrolysis of biosolids is an emerging technology in the United States, with one full-scale facility in operation at Silicon Valley Clean Water in the San Francisco Bay Area (3 biodryers and one pyrolysis unit). Another full-scale facility is current under construction in Rialto, CA. The Rialto Bioenergy Facility was commissioned by Anergia and will process up to 300 tons-per-day of dewatered biosolids through pyrolysis and produce up to 30 tons-per-day of fertilizer. Additionally, a system supplier, KORE Infrastructure, conducted a 6-year pilot test at Los Angeles County Sanitation District that concluded in 2015. KORE is planning for a full-scale system in San Bernardino County with a capacity of reportedly 150 dtpd (Jones et al., 2022).

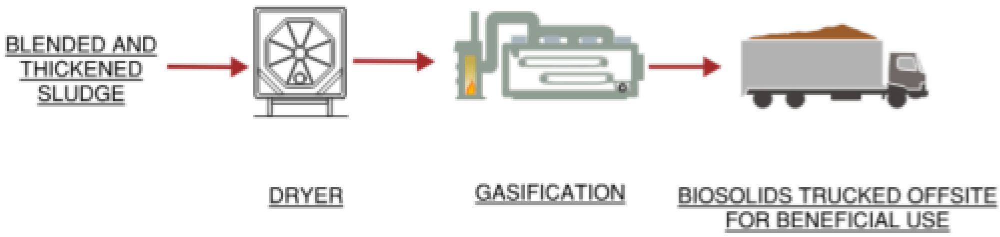


Pyrolysis Basic Unit Configuration

B-39. Gasification

Classification: High Temperature.

Description: Gasification involves heating dried biosolids under low-oxygen environments to produce a combustible gas and soil amendment product. Dewatered solids are sent to thermal dryers, which heat the biosolids and remove most of the moisture. Dried solids are then conveyed to the gasifier. Under oxygen-starved conditions, the gasifier temperature is maintained around 1,500 °F using natural gas or electricity. A controlled amount of air is added to process air recirculated through media to fluidize the solids bed and mix the solids. Through gasification, solids are converted into biochar and a combustible synthetic gas, or syngas. The syngas can be returned to the thermal dryers upstream of the process or can be used for renewable energy production (Jones et al., 2022).



Dryer and Gasification Process Flow Diagram

B-40. Super-Critical Wet Oxidation

Classification: High Temperature.

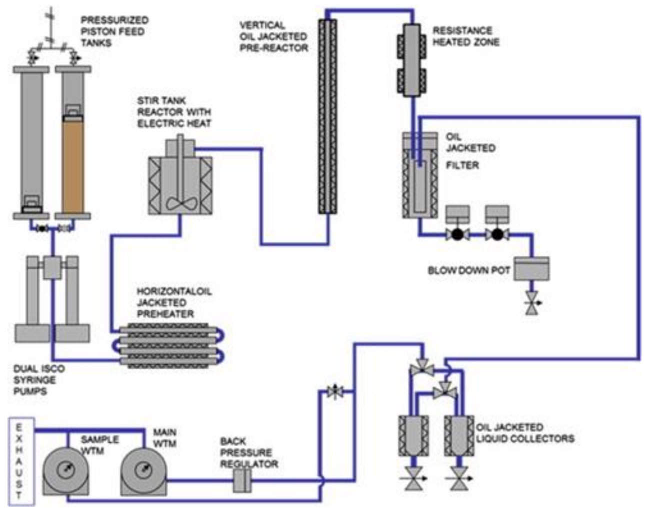
Description: In supercritical water oxidation, water is heated and pressurized above the critical point (705°C and 3,190 pounds per square inch), which significantly increases the solubility of organic substances and oxygen into water. Supercritical water oxidation technology takes advantage of this characteristic to fully oxidize organic substances. This technology produces a high-quality liquid effluent and is capable of producing Class A biosolids. Supercritical water oxidation also may be referred to as "hydrothermal oxidation."

Application of the process in industrial and wastewater treatment facilities is ongoing. The first two units were installed at the Harlingen, Texas, wastewater treatment facility in July 2001 for use in a pilot study. Otherwise, there has been limited application of supercritical water oxidation in North American full-scale wastewater treatment facilities to stabilize raw solids (Dursun et al., 2023).

B-41. Hydrothermal Liquefaction

Classification: High Temperature.

Description: Hydrothermal liquefaction (HTL) uses thermochemical reactions at subcritical temperatures (250-375°C) and pressures (4 to 22 Megapascals) to convert biomass to biocrude . This technology has been under development at the Pacific Northwest National Laboratory (PNNL) as part of a U.S. Department of Energy Program to assess the viability of using various feedstocks such as woody biomass, algae, manure, and sewage to produce a biocrude. To date, HTL has not been able to operate continuously, but instead is a batch process for sewage sludge (Elhassan et al., 2023).



PNNL lab-scale reactor
Source: PNNL 2021

B-42. Anaerobic Lagoons

Classification: Lagoons.

Description: Anaerobic lagoons are deep earthen basins that promote anaerobic conditions for the treatment of high strength organic wastewaters. They are used as pretreatment systems to reduce the organic loading and produce methane gas, which can be used for energy generation. Anaerobic lagoons are not aerated, heated, or mixed, and require a large area of land and a long detention time. They are sensitive to environmental factors such as temperature, pH, and inhibitory substances. The effluent from anaerobic lagoons is not suitable for direct discharge and needs further treatment in aerobic or facultative lagoons.

Anaerobic lagoons are typically used for the pretreatment of high strength industrial wastewater and for the pretreatment of municipal wastewater to allow for preliminary sedimentation of suspended solids. They are especially effective for wastewater treatment facilities that process wastewater for rural communities that have a significant organic load from industrial sources. Anaerobic lagoons are not an applicable technology in some situations due to large land usage and long retention times, sensitivity to environmental conditions, odor control issues (US EPA, 2002b).

Anaerobic sludge lagoons typically operate with one or more years of SRT that often produce the most stable, lowest volatile solids, anaerobically treated solids. This VSR is such that solids have been seen to dewater (drain) to 40 or 50% TS within one hour of being pumped to a passive drainage slab. The biosolids usually meet Class-A pathogen standards but the process has not been accepted by EPA as a process to further reduce pathogens (PFRP, or “Class-A process”).

B-43. Aerobic Lagoons

Classification: Lagoons.

Description: Aerated lagoons are a type of wastewater treatment process that provides oxygen into the system through mechanical surface aerators or submerged diffused aeration. They are classified by the amount of mixing provided, such as partial mix or complete mix. Partial mix lagoons are a subtype of aerated lagoons that provide only enough aeration and mixing to satisfy the oxygen demand of the wastewater, but not enough to keep all solids in suspension. The remaining solids undergo anaerobic fermentation in the lower layers of the lagoon, This reduces the energy consumption and the operational costs of the system. Aerated lagoons are suitable for low to medium strength municipal and industrial wastewaters and require less land than facultative lagoons.

Design and performance of aerated lagoons depend on several factors, such as the number and size of cells, the detention time, the aeration equipment, the temperature, and the loading rate. Aerated lagoons can achieve high BOD removal and moderate TSS removal, but are less effective in removing ammonia nitrogen, phosphorus, and pathogens than facultative lagoons. They also require energy input and maintenance of the aeration devices (US EPA, 2002a).

Aerobic lagoons are more typically used for sewage treatment and there are not readily available examples of it used for sludge treatment.

References

Abbott, T., Kor-Bicakci, G., & Eskicioglu, C. (2021). Examination of single-stage anaerobic and anoxic/aerobic and dual-stage anaerobic-anoxic/aerobic digestion to remove pharmaceuticals from municipal biosolids. *Science of The Total Environment*, *791*, 148237. https://doi.org/10.1016/j.scitotenv.2021.148237

Approaches to Composting. (2023, December 12). United States Environmental Protection Agency. https://www.epa.gov/sustainable-management-food/approaches-composting

Barber, W., Schroedel, R., Shumada, T., Spalding, S., Whitlock, D., & Williams, M. (2019). *High Performance Anaerobic Digestion Fact Sheet*.

BCR Solid Solutions - CleanB. (2021). BCR Solid Solutions. https://bcrinc.com/cleanb/

BCR Solid Solutions - NEUTRALIZER. (2021). BCR Solid Solutions. https://bcrinc.com/neutralizer/

BioCon™ Thermal Sludge Drying System. (2024). Veolia Water Technologies, Inc. https://www.veoliawatertech.com/en/expertise/municipal-market/biosolidsbioenergy/biocon-thermal-sludge-drying

Bioset Process. (n.d.). Schwing Bioset. Retrieved March 4, 2024, from https://www.schwingbioset.com/municipal-products/bioset-process/

Cambi Solidstream: Thermal hydrolysis as a pre-treatment for dewatering - Cambi. (n.d.). Retrieved March 4, 2024, from https://www.cambi.com/resources/literature/cambi-solidstream-thermal-hydrolysis-as-a-pre-treatment-for-dewatering/

Capodaglio, A. G. (2021). Pulse Electric Field Technology for Wastewater and Biomass Residues' Improved Valorization. *Processes*, *9*(5), 736. https://doi.org/10.3390/pr9050736

Dursun, D., Abu-Orf, M., Grijalva, L., & Copp, B. (2023). *Demonstration of Supercritical Water Oxidation to Diversify End Products, Destroy PFAS and Reduce Air Emissions*.

Elhassan, M., Abdullah, R., Kooh, M. R. R., & Chou Chau, Y. F. (2023). Hydrothermal liquefaction: A technological review on reactor design and operating parameters. *Bioresource Technology Reports*, *21*, 101314. https://doi.org/10.1016/J.BITEB.2022.101314

EnVessel Pasteurization. (2023). https://rdptech.com/wp-content/uploads/2023/07/EVPBroch.pdf

Fang, C., Su, Y., He, X., Han, L., Qu, H., Zhou, L., & Huang, G. (2022). Membrane-covered composting significantly decreases methane emissions and microbial pathogens: Insight into the succession of bacterial and fungal communities. *Science of The Total Environment*, *845*, 157343. https://doi.org/10.1016/J.SCITOTENV.2022.157343

García-Cascallana, J., Barrios, X. G., & Martinez, E. J. (2021). Thermal Hydrolysis of Sewage Sludge: A Case Study of a WWTP in Burgos, Spain. *Applied Sciences*, *11*(3), 964. https://doi.org/10.3390/app11030964

High Solids Anaerobic Digestion - TRANSFORM ORGANIC WASTE INTO RENEWABLE ENERGY WITH HIGH SOLIDS ANAEROBIC DIGESTION. (2024). Anergia. https://www.anaergia.com/solutions/municipal-solid-waste/high-solids-anaerobic-digestion/

Jones, A., Pomerleau, M., & Chilson, S. (2022). *Biosolids Gasification Factsheet*.

Kawasaki Sludge Processing System. (2022). https://global.kawasaki.com/en/industrial_equipment/environment_recycling/water/dirt.html#:~:text=Flash%20drying%20machine%20(sludge%20cracking,machine%20with%20high%20heat%20efficiency.

Komoline-Wyssmont Turbo Dryer . (2024). https://komline.com/product/turbo-dryer/

Labatut, R. A., Angenent, L. T., & Scott, N. R. (2014). Conventional mesophilic vs. thermophilic anaerobic digestion: A trade-off between performance and stability? *Water Research*, *53*, 249–258. https://doi.org/10.1016/J.WATRES.2014.01.035

LLaurado, J. G. (2008). Biosolids Treatment Processes: Handbook of Environmental Engineering, Volume 6. *Management of Environmental Quality: An International Journal*, *19*(3), 402–405. https://doi.org/10.1108/14777830810866491

LysoTherm™ - Ovivo Water. (n.d.). Retrieved March 4, 2024, from https://www.ovivowater.com/en/product/lysotherm/

Lystek - Our Technology. (2024). Lystek. https://lystek.com/technology/

McNamara, P., Sabba, F., Redmond, E., Dunlap, P., Worley-Morse, T., Marks, C., & Downing, L. (2022). Post aerobic digestion (PAD) is a solids sidestream nutrient removal process that utilizes native carbon: performance and key operational parameters from two full-scale PAD reactors. *Environmental Science: Advances*, *1*(2), 216–228. https://doi.org/10.1039/d2va00045h

Michel, F., O'Neill, T., Rynk, R., Bryant-Brown, M., Van Calvez, V., Li, J., & Paul, J. (2022). Contained and in-vessel composting methods and methods summary. *The Composting Handbook: A How-to and Why Manual for Farm, Municipal, Institutional and Commercial Composters*, 271–305. https://doi.org/10.1016/B978-0-323-85602-7.00009-1

Michel, F., O'Neill, T., Rynk, R., Gilbert, J., Wisbaum, S., & Halbach, T. (2022). Passively aerated composting methods, including turned windrows. In *The Composting Handbook* (pp. 159–196). Elsevier. https://doi.org/10.1016/B978-0-323-85602-7.00002-9

Oleszkiewicz, J. A., & Mavinic, D. S. (2002). Wastewater biosolids: an overview of processing, treatment, and management. *Journal of Environmental Engineering and Science*, *1*(2), 75–88. https://doi.org/10.1139/s02-010

Pembroke, J. T., & Ryan, M. P. (2019). Autothermal Thermophilic Aerobic Digestion (ATAD) for Heat, Gas, and Production of a Class A Biosolids with Fertilizer Potential. *Microorganisms*, *7*(8), 215. https://doi.org/10.3390/microorganisms7080215

Shafer, P. L., Farrell, J. B., Uhte, W. F., & Robinowitz, B. (1994). *Pre-Pasteurization, European and North American Assessment and Experience*.

US EPA. (2002a). *Wastewater Technology Fact Sheet Aerated, Partial Mix Lagoons*.

US EPA. (2002b). *Wastewater Technology Fact Sheet Anaerobic Lagoons*.

US EPA. (2003). *Biosolids Technology Fact Sheet Use of Incineration for Biosolids Management*.

US EPA. (2006a). *Biosolids Technology Fact Sheet Heat Drying*.

US EPA. (2006b). *Biosolids Technology Fact Sheet Multi-Stage Anaerobic Digestion*. https://www.epa.gov/sites/default/files/2018-11/documents/multistage-anaerobic-digestion-factsheet.pdf

US EPA. (2018). *Biosolids Technology Fact Sheet Alkaline Stabilization of Biosolids*.

Van Caneghem, J., Brems, A., Lievens, P., Block, C., Billen, P., Vermeulen, I., Dewil, R., Baeyens, J., & Vandecasteele, C. (2012). Fluidized bed waste incinerators: Design, operational and environmental issues. *Progress in Energy and Combustion Science*, *38*(4), 551–582. https://doi.org/10.1016/J.PECS.2012.03.001

Wang, X., Andrade, N., Shekarchi, J., Fischer, S. J., Torrents, A., & Ramirez, M. (2018). Full scale study of Class A biosolids produced by thermal hydrolysis pretreatment and anaerobic digestion. *Waste Management*, *78*, 43–50. https://doi.org/10.1016/J.WASMAN.2018.05.026

Weinert, D., & Grosser, A. (2012). Improved Solar Biosolids Dryers. *Proceedings of the Water Environment Federation*, *2012*(2), 789–804. https://doi.org/10.2175/193864712811693641

What We Do - How We Create Good Things from Organic Waste. (2020). Kompogas SLO. https://kompogas-slo.com/what-we-do/

Attachment C: SWEET Model

Operations and Maintenance Assumptions			
Cost Element	**Units**	**Baseline Value**	**Notes for Baseline Values**
Alt A1 THP			
LVH for Digester Gas	Btu/cf	560	typical value
Digester - Cubic ft per VS	cf/lb VS	15	typical value
BFP Capture Rate	%	92%	assumed based on experience
BFP Cake %TS	%	24%	assumed based on experience
BFP Polymer Dose Rate	lb-polymer/dt	21.5	assumed based on experience
Alt B Thermal Drying Process Assumptions			
Heat Content of NG Consumed - Florida 2022 (LHV)	btu/cf	932	Pulled from EIA website on 10/26/23 https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm
Dryer Capture Rate %	%	95%	assumed based on experience
Dryer Pellet %TS	%TS	92%	assumed based on experience
Dryer Btu/lb	Btu/lb	1400	assumed based on experience
Mineral Oil Dose	lb/ton TS	24.0	assumed based on experience
Alt C Composting Process Assumptions			
Consumption rate, small dump truck	miles/gal	4	Based on Steve W information
Miles per day for smaller facility	Miles per day	1	Based on Steve W information
	Miles per day	38.9	assumed 24/7/365
	miles per year	14188.8	calculated
	gal/yr	3547.2	calculated
Bulking Agent Moisture Content, Woody Amendment	%water	40%	Provided by vendor
Initial Mix Moisture Target	%	61%	Provided by vendor
Bulking Agent Volume, Woody Amendment	wtpy	400,000	Provided by vendor
Biosolids Moisture Content	%water	86%	Provided by vendor
Alt D FBI Process Assumptions			
Labor, FTE for Incineration & Steam	FTE	16.25	Provided by Lloyd Winchell 10/6/2023 for NEORSDs FTE
Furnace Power	HP	1,000	Provided by Lloyd Winchell 10/10/2023 based on NEORSD
Markup for hot standby		1.5	assumed based on experience
Alt A1 THP + RNG			
Biogas Upgrading O&M Cost	$/MMBtu	1,100	Value provided by vendor and based on experience
RNG Sale Price	$/MMBtu	$6.38	based on NG supply costs
RNG Broker Fee	%	20.0%	assumed based on experience
RINs Unit Price (D3)	$/RIN	$2.25	https://www.epa.gov/fuels-registration-reporting-and-compliance-help/rin-trades-and-price-information
Alt B2 Solar Drying			
Solar Dryer Cake %TS	%	22%	Assumed min 22% of cake feed to dryers
Solar Thermal Heat Demand	Btu/lb	1,370	Provided by Kenny, scaled using average solar radiation
Solar Dryer Power Demand	HP	150	10 units total at 15 HP each
Thermal Drying Heat Recovery Efficiency	%	22%	Initial assumption