CREATING A SUSTAINABLE BIOSOLIDS MANAGEMENT PLAN

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ABSTRACT

A city with a population of approximately 12,500 operates two advanced wastewater treatment facilities (WWTF) with a combined treatment capacity permitted at 2.75 million gallons per day (mgd). Each facility discharges 100% of the effluent generated onsite to the reuse system for use throughout the city. Biosolids at each facility are aerobically digested and the city uses an independent contractor to dewater and dispose of the residuals.

The process and disposal of the city's biosolids currently meet all state regulations; however, due to changing land application rules and the desire to develop a more sustainable management plan, the city commissioned an evaluation to provide technical guidance and expertise concerning biosolids treatment and process handling from the two WWTFs.

To meet the city's needs, the evaluated processes had to be capable of producing an EPA Biosolids Rule 40 CFR Part 503 Class AA fertilizer. Potential environmental impacts, including odors and vector attraction at the site were also analyzed. A benefit scoring method was used to identify the most promising alternatives.

The evaluation identified a selected process and included an economic analysis of the construction cost of the facility, regulatory and permitting requirements, the expected operation and maintenance costs, the expected quality and quantity of the product and the expected savings and revenue from implementing the change.

In this presentation, attendees will learn how a municipality evaluated and selected a sustainable biosolids management plan, and will review the data the city used—including operations and management requirements and cost estimates of three solar drying options as well as alternative technology options—in making its decision.

KEYWORDS

Treatment; Disposal; Marketing

INTRODUCTION

The City of Mount Dora, Florida (City) has a population of approximately 12,500 and operates two advanced WWTFs. The City discharges 100% of the effluent generated at each facility to its reuse system. Biosolids at each facility are currently processed under a private contract and, as such, the City forgoes any economic or "green" benefits. The City desires improvements to its biosolids system to match its effluent beneficial reuse program.

WWTF #1 is a 1.5-mgd annual average daily flow (AADF) permitted capacity oxidation ditch domestic WWTF. The plant consists of influent screening and grit removal, aeration, secondary

clarification, chemical feed facilities, filtration, chlorination, aerobic digestion of residuals, a 1.558 million gallon (mg) lined reject storage pond, and three lined wet-weather storage ponds with a total volume of 9.337 mg. Waste-activated sludge is dewatered onsite before being hauled offsite for processing.

WWTF #2 is a 1.25-mgd AADF permitted capacity oxidation ditch domestic wastewater treatment plant. The plant consists of flow equalization, influent screening and grit removal, anoxic zones, aeration, secondary clarification, chemical feed facilities, filtration, chlorination and aerobic digestion of biosolids.

Biosolids in Florida are regulated by EPA, FDEP and FDACS. EPA classifies biosolids as Class A or Class B, nationwide. In Florida, Florida Department of Environmental Protection (FDEP) further categorizes Class A as Class AA if Class A pathogen reduction process requirements are met and the biosolids do not exceed specific metal concentrations. Compliance with the Class AA requirement is dependent upon both the pathogen reduction process and an effective industrial pretreatment program for metal concentrations enforced through the local municipality.

Table 1. FDEP Class AA Parameter Concentrations

Parameter	Monthly Average (mg/kg dry weight basis)	Ceiling (mg/kg dry weight basis)
Arsenic	41	75
Cadmium	39	85
Copper	1,500	4,300
Lead	300	840
Mercury	17	57
Molybdenum	-	75
Nickel	420	420
Selenium	100	100
Zinc	2,800	7,500

The City's current operation does not achieve the highest classification level for the liquid biosolids produced from the aerobic digester at each facility. The current biosolids contract is the Residuals Management Agreement with Sweetwater Environmental, Inc. (SEI). The contract simply requires SEI to dewater and dispose of liquid biosolids from the two facilities received at up to 3% solids.

The purpose of this evaluation is to explore cost-effective, environmentally friendly technologies that comply with regulatory restrictions impacting biosolids disposal. The goal of the proposed improvements to the City's biosolids system is to select a sustainable solution in order to achieve a Class AA product under a Mount Dora Biosolids Management Program.

DISCUSSION

While regulatory and compliance issues are an important element of the City's biosolids management program, the beneficial use of the end product requires viable outlets or markets for

the desired Class AA material. Class AA products currently generated in Florida include composted materials, lime stabilized/pasteurized product, heat-treated and pelletized products, and digested product meeting requirements established by both EPA and FDEP. Class AA product can be applied to land for agricultural purposes; used internally by the City for landfill cover, backfill, fertilizer or other applications; distributed and marketed; or used for land reclamation.

The primary agricultural activities near Mount Dora include pasture and hay lands, orchards and groves, and many small ranches. The addition of a biosolid-derived product can be a beneficial source of essential nutrients for the plant materials raised in the area. Land management activities devoted to agriculture indicate a reduction in cultivated land between the 2002 and the 2007 census of agriculture (United States Department of Agriculture [USDA] Census of Agriculture).

Land areas in Lake County are well suited to receive biosolid materials. Based on the USDA Census of Agriculture, adequate land mass is available in the Lake County area to accommodate the municipal biosolid material with little competition from other operations. The 6,000+ acres of pasture and 12,000 acres of grove can accommodate the small volume of biosolid material generated from Mount Dora.

Measurements of nutrients, metals and potential lime content are critical in determining agricultural end uses. The values are presented on a dry ton basis. Note that lime addition is required to produce lime stable products, and the range in lime content is determined by the specific process utilized. Where quicklime (CaO) is added to both adjust pH and provide heat through the hydration reaction, very high lime levels are achieved, but where lime is added to adjust pH and external supplemental heat is added to provide pathogen destruction, the lime content is low and the material is a more balanced nutrient source.

Table 2. Anticipated Biosolid Nutrient

Nutrient	Solar Drying	Digestion	Lime Pasteurization
Nitrogen (N)	2%-4%	2%-4%	2-3%
Phosphorus (P)	1%	1%	0.5%-0.75%
Potassium (K)	0.25%	0.25%	0.2%
Lime (as CCE)	0.2%-0.5%	0.2-0.5%	40-60%
CCE is Calcium Carbonate Equivalence, a measure of lime value			

Listed here are typical nutrient levels associated with the residuals treatment processes being compared.

Nutrient loadings to pasture grasses and hay lands are determined by the site management practice. Grazed pasture lands with traditional livestock stocking densities are permitted to receive an additional 50 pounds of nitrogen per acre per year. Grazed pasture lands with low stocking densities and some hay harvest are permitted to receive up to 100 pounds of nitrogen per acre per year. Hay lands that are cropped optimally are allowed an additional 160 pounds of nitrogen per acre per year. Each of these scenarios presents opportunity to beneficially utilize a Class AA biosolid product.

Soil materials on many pasture lands are typically acidic with a soil pH below 7. Many pasture sites exhibit soil pH below 6. Optimum pasture productivity is achieved with soil pH in the 6.5 to 6.8 range. In addition to nitrogen, many pasture sites require addition of liming material to adjust soil pH upward. Pasture grasses common in the Lake County area include Bahia grass and hybrid Bermuda grass, which are warm-season grasses well suited to the warm climate in the area. The Lake County Agricultural Extension office has indicated that the local agricultural community highly values the biosolid material lime content. This suggests a potential market for biosolid-derived product containing both nutrients and lime. Typical loading to pasture lands for the products listed are presented in Table 3.

Table 3. Biosolid Loadings

Process	50 lb/ac – N	100 Lb/ac - N	150 lb/ac - N	1 Ton Lime
Solar Drying	0.5-1.2 tons	1.25-2.5 tons	2.5-5 tons	160-350 tons
Digestion	0.5-1.2 tons	1.25-2.5 tons	2.5-5 tons	160-350 tons
Lime Pasteurization	5-8.5 tons	10-17 tons	20-34 tons	1.25-2 tons

Biosolid loadings noted as tons per acre per year (tons/ac/yr) to supply nutrient and lime for pasture and hay lands in Lake County.

To supply essential nitrogen on a well-managed pasture, approximately 5 tons of biosolid-derived product could be applied to each acre available annually. Similarly, the tonnage of a lime product would be 20 to 30 tons to supply the appropriate quantity of nitrogen, but only 2 tons would be required to supply the required lime. However, addition of lime product to supply nitrogen would elevate soil pH appreciably and well above optimum for pasture grass production. The tonnage of compost, a very low-level nutrient source, would require addition of 10 to 15 tons of biosolid-derived product to supply nutrients to harvested hay lands.

If the material were applied onto high-quality, harvested pasture at a rate of 5 tons/acre annually to satisfy nitrogen requirements, then the land area required to accommodate the annual biosolids production is approximately 300 acres. The required land mass increases to over 900 acres if grazed pasture, with the 50 lb-N/ac load, is used as the receiver. These typical values suggest allowable loadings of 5 tons per acre on well-managed hay lands or ungrazed pasture where forage is harvested and removed.

Modern agricultural systems require development of Comprehensive Nutrient Management Plans (CNMP). These plans are developed to optimize crop production while reducing the potential for nutrients to migrate below the root zone of plant materials or to surface water as runoff. Elements in a nutrient management plan must address the form of the nutrient, whether an organic or inorganic source; the loading rate to crops and the realistic yield expectation for the soil on a receiver site; the placement of those nutrients on the soil surface or below the surface; and the timing of the nutrient addition. Optimum timing of nutrient additions is within 30 days of plant germination or during the early growth stage of the maturing plant. Once plant materials mature, nutrient needs fall.

The CNMP for Mount Dora biosolid material must address the form, timing, placement and loading based on realistic crop yield. These loadings are based the 50, 100, and 150 pounds of nitrogen per acre per year as described by Lake County Extension. Biosolid product loads of 5

tons/acre are recommended based on typical values for biosolid materials. Actual loadings for the material generated at Mount Dora must be developed through pilot or bench scale assessments of product generated by the desired process and utilizing biosolid from Mount Dora. The Class AA product to be generated at Mount Dora will be registered through the Florida Department of Agriculture and Consumer Services (FDACS) as a fertilizer material.

METHODOLOGY

The evaluation was a phased approach with an initial list of three solar drying manufacturers and the following eight treatment technologies:

- Aerobic digestion
- Anaerobic digestion
- Biogasification
- Composting
- Incineration
- Pasteurization
- Thermal drying
- Thermal hydrolysis

The three solar drying manufacturers remained in the second phase and the other treatment technologies were narrowed to two technologies for further review based on the results of the local assessment ranking survey. Aerobic digestion and anaerobic digestion were the two selected treatment technologies. Based on the ranking results, lime pasteurization was included as a third alternative technology treatment option for review.

The initial evaluation was based on the current AADF at each facility with a total amount of biosolids material generated of approximately 1,420 pounds/day or 260 tons/year. The final evaluation was amended to calculate the biosolids treatment based on the permitted capacity at each facility. At Mount Dora's total permitted capacity of 2.75 mgd, the amount of biosolids material generated from each facility is approximately 4,200 pounds/day or 767 tons/year.

Solar Drying

The premise of solar drying technology is to harness energy from the sun in order to remove moisture from the biosolids. Solar drying can reduce sludge volume, but the extent of volume reduction is dependent upon the incoming sludge solids content as well as local weather conditions. Dewatering prior to the solar-drying process is a requirement of the system. Solar drying has an intrinsic low energy cost and can produce up to a 90% dry solids content.

The solar-drying process meets 503 Rule pathogen reduction requirements under the equivalent process to a PFRP alternative. The 503 Rule vector attractor reduction (VAR) requirements are met when the percent solids are greater than or equal to 75%.

However, the process does not provide for treatment of the source of potential odors within the product. Depending on the type or lack of "upstream" biosolids treatment process, solar drying

has the potential to produce odors from the odor-causing compounds present in the sludge. Odor-control systems are available but do not provide any treatment of the biosolids. An odor-control system only works in an enclosed building. The system is sized to treat the air within the building, while the odor-causing compounds remain in the material. If the problem is not addressed pre- or post-solar-drying processing, the biosolids have the potential to produce an odor off-site when land-applied.

The following solar drying manufacturers were assessed in this evaluation:

- Parkson Thermo-System, Fort Lauderdale, Florida
- SolOrganics, Clermont, Florida
- Veolia/Kruger Solia, Cary, North Carolina

Each of the three solar drying manufacturers was requested to provide a revised proposal based on the following parameters:

- 33,000 gpd at 10.5% solids output, the current solids output from the recently installed dewatering boxes at WWTP #2
- 32,000 gpd at 15% solids output from a belt-filter press
- 29,000 gpd at 21% solids output from a centrifuge

Parkson Thermo-System
The Parkson Thermo-System solar-drying process utilizes an enclosed building with a polycarbonate transparent cover. The system's process is fully automated with an automatic sludge tilling machine that turns, distributes and aerates the sludge. Operation of the tilling machine, or Electric Mole®, is automated through a control system that monitors the drying process. An optional odor-control system is available. The Parkson Thermo-System has been installed in 13 locations throughout the US and has over 150 total installations worldwide.

Parkson provided a revised proposal with three influent dry solids: 10.5% (Case 1), 15% (Case 2), and 21% (Case 3), and a final dry solid of 75%. The revised parameters are shown in Table 4.

Table 4. Parkson Thermo-System Preliminary Design Information

Parameter	10.5% (Case 1)	15% (Case 2)	21% (Case 3)
Chamber Dimensions (ft)	42 x 204	42 x 204	42 x 204
Drying Area / Chamber (ft^2)	8,568	8,568	8,568
Number of Chambers	7	5	3
Total Drying Area (ft^2)	59,976	42,840	25,704

The system also includes an air ventilation system with an electric "fresh air" air flap, aeration fans and exhaust fans; one Electric Mole® to mix and aerate per chamber; a control system; and an odor-control system.

SolOrganics
SolOrganics' current system utilizes an open greenhouse for natural ventilation and requires manual turning of the sludge by a tractor. A rotating drum composter is used post-solar drying to

accelerate the composting process for approximately 72 hours, dependent upon influent sludge solids content. Use of the rotating drum composter allows SolOrganics to meet Class A pathogen reduction requirements under the Process to Further Reduce Pathogens (PFRP) composting alternative without any pretreatment of the residuals. SolOrganics has one open greenhouse with natural ventilation installation located in Clermont, Florida. This facility is receiving pre-digested solids from domestic wastewater facilities and is producing a Class AA registered fertilizer product that is used on its own low density pasture lands. SolOrganics is currently receiving material that ranges from 8% to 21% dry solids.

For the three solids output options requested at 10.5%, 15%, and 21%, SolOrganics provided one revised proposal for an enclosed greenhouse with an odor-control system. The revised proposal did not include any additional adjustments from the original proposal, which included one 8-ft. by 40-ft. rotary drum composter; rolling stock comprised of a tractor for mixing and aerating and a skid steer for loading the rotary drum composter; an odor-control system; and a third building for the composter, rolling stock and finished product storage.

Veolia/Kruger Solia

The Veolia/Kruger Solia solar-drying process uses either an open or enclosed greenhouse with a polycarbonate transparent cover. The system uses a sludge-turning system to evaporate water from the sludge. The sludge-turning system uses windrows to increase the surface area between the sludge and the air and ensure sludge traceability control. Operation of the sludge-turning system or the Soliamix® windrow turner can be automated or controlled by an operator. An in-vessel composter is included to meet Class A requirements under the PFRP composting alternative without any pretreatment of the residuals. An optional odor-control system is available. The Veolia/Kruger Solia process has not been installed in the US, but has over 150 installations worldwide.

Veolia/Kruger provided a revised proposal at an influent dry solid of 15%, and 21%, and a final dry solid of 75%. The revised parameters are shown in Table 5.

Table 5. Veolia/Kruger Solia Preliminary Design Information

Parameter	**15%**	**21%**
Bay Dimensions (ft)	49.4 x 348	49.4 x 228
Drying Area / Bay (ft^2)	17,197	11,267
Number of Bays	2	2
Total Drying Area (ft^2)	34,394	22,534

The system also includes a wet sludge storage silo, progressive cavity feed pumps, one Soliamix® windrow turner, an automated drying air ventilation system comprised of inlet louvers and extractor fans, a mixing air ventilation system, an in-vessel composter, a control system, and an odor-control system.

Alternative Technologies

Aerobic digestion and anaerobic digestion meeting EPA's Class A requirements were the two alternative technology options selected for evaluation to improve the City's biosolids system.

Lime pasteurization was included as a third alternative technology treatment option for review, based on the local assessment ranking results.

While the City currently operates an aerobic digester at each facility, neither operates at the parameters required to meet Class A requirements. Each type of digestion uses organisms to reduce or breakdown the suspended solids in the waste-activated sludge at various temperatures. Aerobic digestion takes place in an oxygen-rich environment, while anaerobic digestion occurs in a system without oxygen. The amount or mass of biosolids generated from a site is reduced in either digestion process by various organisms. In addition to mass reduction, the Class A time and temperature requirements are met, based on flow and tank volume for time, as well as operation at one or a combination of the following elevated temperatures:

- Mesophilic typically between 20°C and 45°C (68°F and 113°F)
- Thermophilic typically between 45°C and 122°C (113°F and 252°F)

The digestion goal is to stabilize and reduce the solids mass, reduce pathogens to EPA 503 Class A levels, and reduce or eliminate odors.

Aerobic Digestion
Aerobic digestion utilizes bacteria that thrive in an oxygen-rich environment to decompose organic matter. The aerobic organisms use waste-activated sludge with a supplemental oxygen source to produce stable solids, carbon dioxide, and more organisms. In general, aerobic digestion requires tankage, an oxygen source, an aeration delivery system and mixing pump(s). Foam control pump(s) and an odor-control system may be required, as aerobic digestion has the potential to produce both foam and odors. Utilizing a supplemental oxygen source and delivery system accelerates the aerobic digestion process, resulting in decreased tank volume.

The Autothermal Thermophilic Aerobic Digestion (ATAD) system is a specific aerobic digestion process that meets EPA Class A requirements. The ATAD process is self-heating or "autothermal" and does not require an external heat source. The operating temperature is in the thermophilic range, at 55°C or higher. The process requires two covered tanks—a higher temperature first stage and a second stage at a lower temperature—as well as an oxygen source, an aeration delivery system, mixing pump(s), foam control pump(s) and an odor-control system.

Aerobic digestion is a widely used form of digestion and the ATAD process provides numerous benefits, including the following:

- Class AA biosolids material
- Produces a low odor product
- 60-65% volatile suspended solids (mass) destruction
- Significant volume reduction
- Improved biosolids dewaterability

The following are two companies that provide second generation ATAD systems:

- ThermAer by Thermal Process Systems (TPS), Crown Point, Indiana

- FUCHS, Mayen, Germany with US representation by Kusters Water, Spartanburg, South Carolina

The TPS ThermAer ATAD process utilizes two tanks: a covered thermophilic first stage ThermAer tank, followed by a second stage jet-aerated storage nitrification denitrification tank. The process can be operated manually or as an automated process, and requires a minimum total solids of 5%. The TPS ThermAer system has been installed at 24 locations throughout the US.

TPS proposed utilizing the existing aerobic digester at WWTP #2 for the second stage tank. The system consists of a new 21.5-ft. diameter, 24-ft. deep first stage covered tank, associated equipment for both the new first stage tank and the existing second stage tank, and an odor-control system. TPS also proposed a ThermAer Sludge Dryer, an open air drying system similar to a solar-drying process. The ThermAer Sludge Dryer consists of a 50-ft. by 60-ft. structure, heat exchanger and tractor.

Anaerobic Digestion

Anaerobic digestion utilizes bacteria in an oxygen-free environment to decompose organic matter. The anaerobic organisms use waste-activated sludge and an external heat source to produce stable solids and a biogas composed primarily of methane and carbon dioxide. The anaerobic digestion process requires tankage, an external heat source, heat exchanger, mixing system, and an odor-control system, due to the generation of odors during the process. While a supplemental oxygen source is not required due to the anaerobic condition requirements, anaerobic digestion does not "self-generate" heat and an external heat source is required. Typically, the off-gas is captured and ignited by a burner to heat the recycle mixing stream in a heat exchanger to provide a supplemental heat source for this process.

The following anaerobic digestion processes meet EPA Class A parameters; two phase anaerobic digestion process (2PAD) and temperature-phased anaerobic digestion (TPAD). Each is a two-stage process with a heat or thermophilic phase followed by either an acid phase for 2PAD or a mesophilic phase for TPAD. Both anaerobic digestion processes require a covered feed tank, a covered thermophilic digester tank and a covered acid or mesophilic digester tank, an external heat source, heat exchanger, mixing system, and an odor-control system.

Anaerobic digestion transforms wastewater pollutants into methane, carbon dioxide and biosolids. The amount or mass of biosolids generated is much lower compared to the aerobic digestion processes. Anaerobic digestion provides the following benefits:

- Class AA biosolids material
- Excellent volatile reduction
- Maximizes pathogen destruction
- Generates gas production

The following are two companies that provide 2PAD or TPAD systems:

- Infilco Degremont, Inc., Richmond, Virginia
- Siemens/Envirex, Waukesha, Wisconsin

Lime Pasteurization

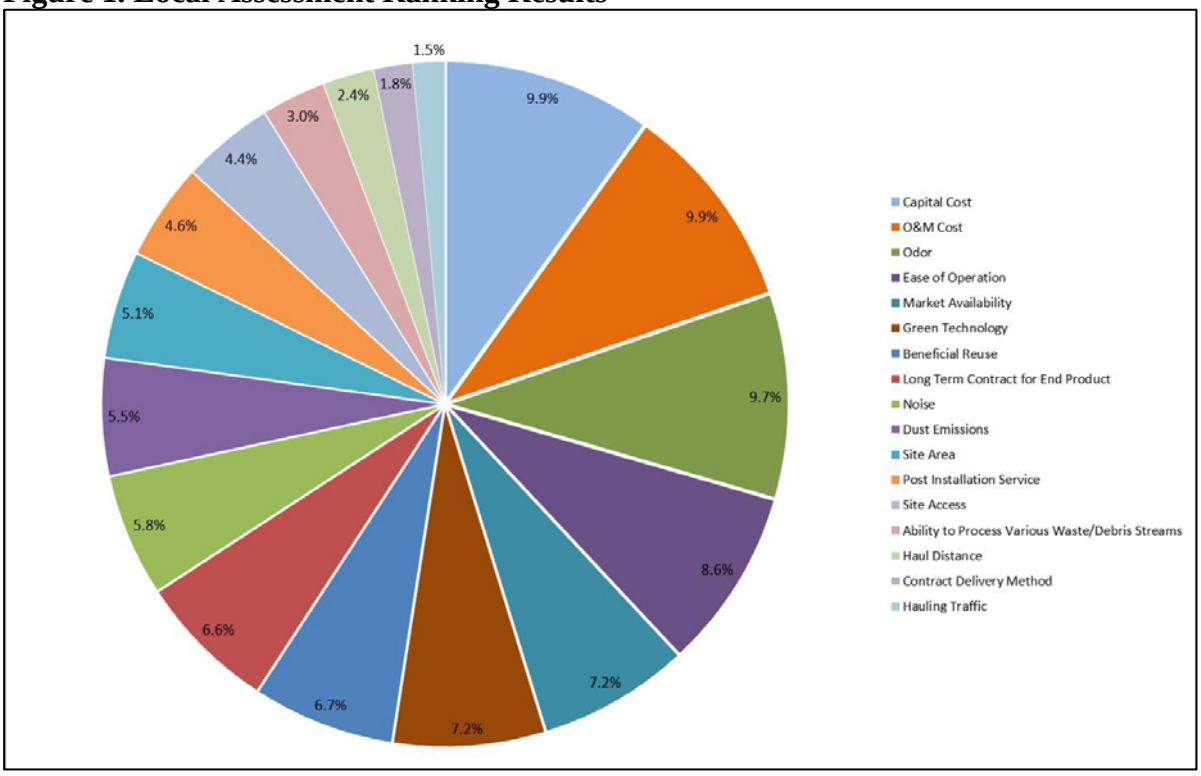
Lime pasteurization is a defined process under the 503 Rule for pathogen reduction and VAR. FKC Co., Ltd. (FKC) of Port Angeles, Washington has a Class A simultaneous dewatering and pasteurization system comprised of a lime/sludge mixing tank, flocculation tank, rotary screen thickener and a heated screw press. Lime is added to the liquid biosolids to raise the pH to 12 and meet VAR. Next, biosolids are flocculated with a polymer and prethickened in a rotary screen thickener. Lastly, the biosolids are fed to a steam-heated screw press where the temperature is maintained at 70°C (158°F) or higher for 30 minutes or longer to meet the pasteurization pathogen reduction option. In addition to pasteurization, the screw press also dewaters the biosolids from 30% to 50% dry solids.

There are 10 FKC Class A system installations in the US, with five of those systems in Florida. There are an additional four FKC screw press installations in operation in Florida.

CONCLUSIONS

The selection of the various technologies evaluated was based on an interactive approach with the City. The process began with an Interactive Options Meeting with City staff to review the options under consideration. Afterwards, a local assessment ranking survey was submitted to eight staff members to determine the importance of various criteria. An analysis of the data shows the top three concerns for the City as capital costs, operation and maintenance costs and odor. The results of the local assessment rankings are shown in Figure 1.

Figure 1. Local Assessment Ranking Results

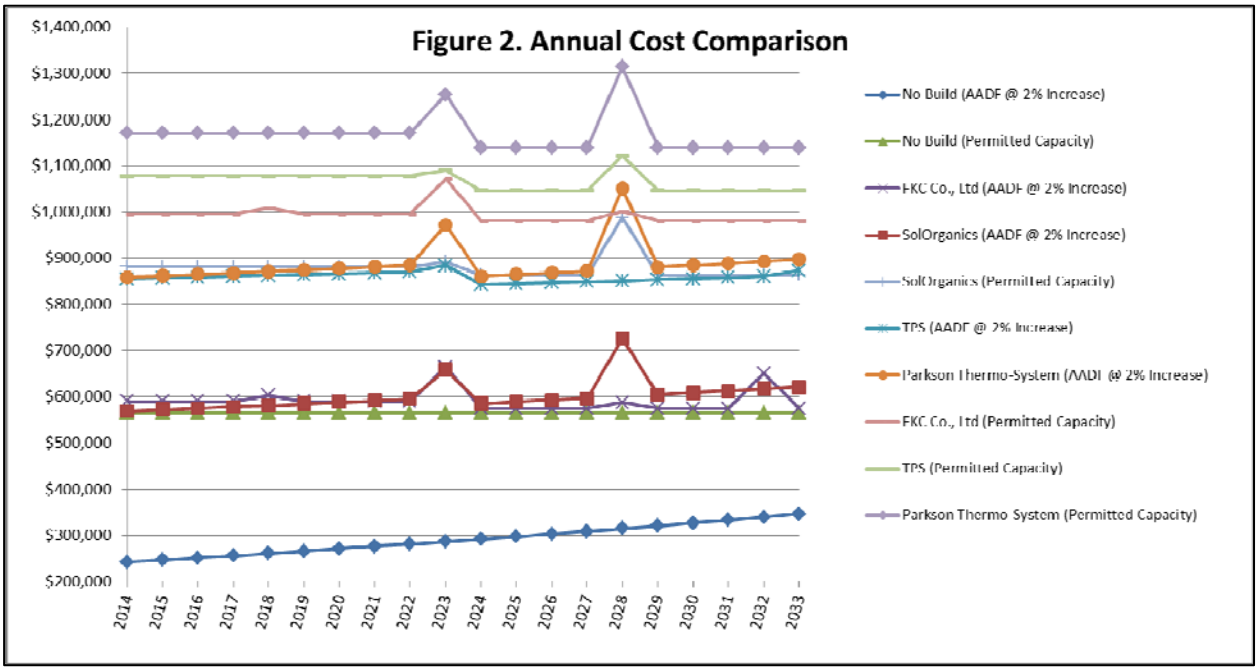


Based on the results, the City desires a low capital and O&M cost technology capable of producing a Class AA product. The rankings reflect the City's concern with potential odors both onsite and at a land application site.

An economic analysis was conducted on the following options at both permitted wastewater treatment capacity and annual average daily flow (AADF) with an annual 2% increase over 20 years at each facility:

- No-build
- Solar Drying – Parkson Thermo-System
- Solar Drying – SolOrganics
- Aerobic Digestion – TPS
- Lime Pasteurization – FKC Co., Ltd

The results of the local assessment rankings are shown in Figure 2.



The solar-drying analysis was based on the City's current use of dewatering boxes and a solids output value of 10.5%. Veolia/Kruger Solia did not provide a 10.5% solids output proposal and therefore was not included in the economic analysis. In addition, anaerobic digestion was not included in the economic analysis due to no receipt of a cost proposal.

The recommendation of the evaluation is for the City to proceed with the design, permitting and construction of a new solar drying facility at WWTP #2. While the no-build option has a lower annual operating cost as well as no capital cost outlay, the City ultimately does not control the operating costs of this option since the pricing is driven by the hauling contractor. The economic analysis for the no-build option utilized the existing SEI rate structure in both the permitted

capacity scenario and the AADF scenario, but the contract is not for a 20-year period. A new solar drying facility greatly reduces the cost uncertainty of a long-term contract under the no-build option.

The new solar-drying facility option does include a hauling contractor component in order to transport waste-activated sludge from WWTP #1 to WWTP #2, but the volume is less than the no-build option. In addition, the disposal cost for each of the treatment options (solar drying, anaerobic digestion and lime pasteurization) does not calculate "no cost" or even revenue generation to the City, but is simply a cost to haul the end product. It is reasonable to expect that the City's disposal cost may be reduced or even eliminated and replaced with generation of revenue based on the solar drying facility Class AA product. Note that the costs to haul biosolids from one facility to another for treatment, as well as the disposal cost or revenue generation, do not impact the capital cost for each option. The following actions are recommended to the City for a new solar drying facility:

- Purchase and install dewatering boxes at WWTP #1
- Initialize coordination with the FDEP Central District about the City's intent to install a solar-drying facility
- Conduct an evaluation to purchase truck to transport or extend or renew a long-term hauling contract for material transport from WWTP #1 to WWTP #2
- Secure both Class AA disposal transport and location options
- Issue a Request for Proposal to design and permit a solar drying facility

The solar drying facility option also allows the City to produce a Class AA product while meeting the top three local assessment rankings of capital cost, O&M cost and odor control. The selected option enables the City to control its biosolids management costs while meeting current regulatory requirements.

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REFERENCES

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