INTEGRATED MASTER PLAN *for the* MAIN WASTEWATER TREATMENT PLANT

C90: Biosolids Management Alternatives

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EBMUD

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EXECUTIVE SUMMARY

The goal of the East Bay Municipal Utility District's (District) Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan Project (Master Plan) is to provide a 30-year roadmap for the MWWTP that addresses future regulations, aging infrastructure, capacity constraints, and climate change. This report focuses on biosolids management alternatives for the 30-year planning horizon and identifies capital improvement program projects to provide the District with a cost-effective and reliable biosolids management program that is adaptable to future regulations.

As part of the Master Plan, biosolids management alternatives were identified, developed, and evaluated against criteria developed for the overall Master Plan. Alternatives were selected to be carried forward, and a phasing and implementation plan for the Integrated Roadmap Report was developed.

The purpose of this report is to review the:

- Universe of biosolids management alternatives that were considered and screened to select five alternatives to carry forward and develop.
- Development and evaluation of the biosolids management alternatives.
- Selection of the long-term biosolids management alternatives that were carried forward into the Integrated Roadmap Report.

Overview of Regulations and Market Trends

The District beneficially uses biosolids produced at the MWWTP through land application, landfill alternative daily cover (ADC), and in the production of compost at an offsite facility. In 2018, 77% of biosolids were land applied, 10% were used as ADC, and 13% were processed at an offsite compost facility. Local ordinances and agricultural practices limit the District's ability to land apply during wet weather months, during which time biosolids have traditionally been managed as landfill ADC. Recent regulations, most notably those resulting from Senate Bill (SB) 1383, have sought to divert organics, including biosolids, from landfills, making it challenging and expensive to manage the District's biosolids in landfill outlets. Diversion of organics from landfills represents a major market and regulatory shift that is unlikely to change and would drive the District to consider alternative means of wet weather management of biosolids.

For the Master Plan, biosolids management alternatives were identified and developed around the following key considerations and regulatory endpoints:

- **Continued land application of Class B cake:** Currently, there are no concerns with land application capacity in Northern California. Class B land application is considered a secure end-use throughout the Master Plan timeline. As such, there is currently no driver to develop a Class A product for the specific purpose of maintaining/expanding land application.

- **Phasing out of ADC/landfill disposal for wet weather biosolids management:** ADC and landfill disposal are management options that the District and most Bay Area publicly owned treatment works have relied upon during the wet weather season. These outlets are no longer considered reliable based on landfill limits on acceptance of high-moisture wastes and regulations associated with SB 1383. While the District may wish to continue to use landfills as an emergency backup outlet, the cost of this outlet will likely be high and unreliable. There is a need to identify alternative wet weather management options.
- **Development of a Class A product**: As noted previously, there is no clear need to develop a Class A product for land application; however, a Class A product, possessing different aesthetic traits from the current Class B cake, could provide the following benefits: program diversification, potential reduction in transportation costs (with volume reduction technologies), and expansion of beneficial use markets that are consistent with statewide goals (e.g., Healthy Soils Initiative, Natural and Working Lands Plan, etc.).
- **Adaptability to emerging PFAS regulations:** There is regulatory uncertainty around the impact of per and polyfluoroalkyl substances (PFAS) regulations on land application. Regulatory impacts at the state level should become evident within the next 3 to 5 years, and federal regulations are expected to be promulgated within a similar timeframe. There is potential that future PFAS regulations could limit land application rates or trigger the need for out-of-state land application. Both potential outcomes would have the potential to increase hauling distances and land application costs.

Alternatives Analysis

A comprehensive list of 15 biosolids management technologies was developed and is referred to as the “universe of alternatives.” The technologies were screened with input from District Staff against criteria shown in Table ES-1.

Table ES-1. Screening criteria

Screening Criteria	Description for Pass/Fail	Metric[a]
Ability to Meet Regulations	Complies with near-term biosolids regulations, supports beneficial use, and can be adapted to meet anticipated regulations.	Pass/Fail
Technology Maturity and Risk (at this size)[b]	Proposed technology/approach has at least one installation with a capacity of 20 million gallons per day (14 dry tons per day) or greater, with at least one year of successful operation (within the last 10 years) at 90% capacity.	Pass/Fail
Ease of Permitting	Technology has been permitted at a wastewater treatment plant (WWTP).	Pass/Fail
Site Constraints	Structures, equipment, etc., fit within the existing WWTP boundaries.	Pass/Fail
Independent Operations	Facilities can be fully operated by District Staff (i.e., contract operations by independent entities is not required).	Pass/Fail
End-use Diversification[c]	Provides new end-use markets beyond status quo (Class B land application and landfill ADC)	Pass/Fail

a. The screening criteria were applied on a pass/fail basis – the alternative either meets the criteria (Pass) or it does not (Fail). Alternatives must meet all criteria to be considered viable and evaluated further.

b. To facilitate screening, technologies were grouped into three categories of technology maturity: embryonic, emerging, and established. Technology status is defined in Chapter 5.

c. Criterion was considered for biosolids alternatives to provide additional differentiation of alternatives, as needed.

The results of the technology screening are summarized in Table ES-2. The following provides additional details on select technologies that were eliminated during the screening process:

- Greenhouse-style solar drying failed the screening step because it was found to have limited value or marketability in new end-use markets. For this reason, it was eliminated from further consideration.
- The Class A anaerobic digestion technologies fit on the site and are established; however, these technologies were eliminated from further consideration because there is no anticipated regulatory driver and end-use benefit that would require a Class A cake for land application.
- Composting is an established technology; however, it was eliminated from further consideration due to the land requirements and the product volume, which increases through the process due to the addition of a bulking agent. The value and marketability of a biosolids-derived compost was also identified during the market assessment to be reduced in future years because the market is expected to be flooded with compost products (organic or non-biosolids-derived products).

Table ES-2. Biosolids technology screening results

Technology	Technology Status	End-use Market	Pass/Fail and Key Considerations
Pre-Digestion Technologies			
Thermal hydrolysis process (THP)	Established	• Land application • Soil blending[a] • Bulk horticulture[a]	Pass: • Potential new end-use markets • Increases capacity of digesters • Improves cake quality
Digestion Technologies			
Temperature-phased anaerobic digestion	Established	• Land application	Fail: • Class A cake does not open new end-use markets
Thermophilic batch anaerobic digestion	Established	• Land application	Fail: • Class A cake does not open new end-use markets
Class A high-solids anaerobic digestion (8% – 10%)	Established	• Land application	Fail: • Class A cake does not open new end-use markets
Post-Digestion Technologies			
Thermal drying	Established	• Land application • Bulk horticulture • Fertilizer blending • Soil blending[a] • Specialty markets[b]	Pass: • Opens new end-use markets • Small footprint • Reduces volume of biosolids product
Open composting	Established	• Land application • Bulk horticulture • Specialty markets[b] • Soil blending	Fail: • Difficult to air permit as open facility • Large footprint • Increased product volume • Potential for decline in compost demand due to market saturation

Technology	Technology Status	End-use Market	Pass/Fail and Key Considerations
Enclosed composting	Established	• Land application • Bulk horticulture • Specialty markets[b] • Soil blending	Pass: • Opens new biosolids end-use markets Key Considerations: • Large footprint • Increased product volume • Potential for decline in compost demand due to market saturation
Chemical thermal hydrolysis (referred to herein as Lystek)	Established	• Land application	Pass: • Potential to open new end-use markets • Extends land application season
Incineration	Established	• Landfill	Fail: • Difficult and long process for air permit
Drying beds	Established	• Land application	Fail: • Difficult to permit • May not produce Class A; overall quality of product may impact ability to use in new end-use markets • Odor potential • Large land requirement
Greenhouse-style Solar Drying	Emerging	• Land application	Fail: • May not produce Class A and overall quality of product may impact ability to use in new end-use markets
Pyrolysis	Emerging	• Land application[a] • Bulk horticulture[a] • Soil blending[a] • Specialty markets[a]	Pass: • Opens new end-use markets • Reduces volume of final product Key Consideration: • Emerging Technology: Several technology offerings installed or under installation at smaller facilities
Gasification	Embryonic	• Landfill • Land application	Fail: • Embryonic technology when only biosolids are used as feedstock

a. Non-established market that needs to be developed to confirm demand and value.
b. Specialty markets include uses such as landscaping and golf courses.

Four technologies (THP, thermal drying, Lystek, and pyrolysis) were developed as alternatives together with three additional biosolids management alternatives (status quo, modified status quo, and merchant facilities) as follows:

- **Status Quo (Alternative 0):** This alternative consists of the District continuing to produce Class B biosolids and beneficially using them. The status quo alternative assumes 50% of the annual biosolids produced are land applied and the remaining 50% are diverted to merchant facilities. Landfill disposal and ADC were not considered to be reliable options in the future. This alternative minimizes new facilities at the MWWTP.
- **Modified Status Quo (Alternative 0A):** This alternative assumes the District continues to produce a Class B biosolids cake. During wet weather months when land application is not viable, the cake would be hauled by a contractor to a District-owned and operated offsite storage facility. Four months of cake storage was assumed at District-owned property in Pinole. The location of the storage facility would need to be verified with a siting analysis. During dry weather months, a third-party contractor would land apply the District's biosolids. To provide biosolids management flexibility, 15% of Class B cake was assumed to be diverted to a merchant facility. Sludge screening at the MWWTP was also included to improve cake quality.
- **Merchant Facilities (Alternative 1):** Under this alternative, the District would produce a Class B cake and all cake would be diverted to offsite merchant facilities. The merchant facilities would provide additional processing or storage and the biosolids product would be beneficially used. There currently are no firm plans for a new merchant facility in the region and there is limited capacity in the existing merchant facilities. This alternative would require either a new facility to be built or the District would likely have to increase hauling distances. This alternative minimizes new facilities at the MWWTP but provides the District with significantly less control of biosolids management costs.
- **Pre-Digestion, THP (Alternative 2):** Under this alternative, the THP process would treat primary sludge, waste activated sludge, and high-strength waste. The THP process has the benefit of increased volatile solids reduction, increased biogas production, and improved dewaterability. THP also has the benefit of increasing digester capacity; in 2050, the District would only need to operate six anaerobic digesters (includes one digester for redundancy). Seismic upgrades to the second-stage digesters could be avoided and would not need to be completed and were identified as an avoided cost. The Class A THP cake would be land applied with the intent of developing the soil blending market as a new end-use.
- **Thermal Drying (Alternative 3):** This alternative consists of adding a post-digestion thermal drying process at the MWWTP. The thermal dryer would produce a pellet that could be land applied or beneficially used in new markets (i.e., soil and fertilizer blending, horticulture, specialty markets). The volume reduction achieved with thermal drying would make onsite storage (4 months) feasible from a cost and space-planning perspective.
- **Lystek (Alternative 4):** This alternative would consist of adding the Lystek process, which would produce a pumpable, liquid Class A product that would be land applied during dry weather months. The Lystek product can be land applied for a longer dry weather season compared to cake. The facility would be owned and operated by the District, and Lystek

would be responsible for beneficial use of the product. Onsite storage of the product during wet weather months was considered, together with seasonal operation of the Lystek facility.

- **Pyrolysis (Alternative 5):** This alternative would consist of a post-digestion pyrolysis system at the MWWTP. Pyrolysis is an emerging technology and there are limited operating facilities that process only biosolids. Depending on the process configuration, pyrolysis can produce biochar, which can be used in a variety of end-use markets, and "syngas", which can be used to heat the pyrolysis reactor or be refined for use as a fuel.

The alternatives were developed and evaluated using economic (net present value [NPV]) and non-economic criteria. The capital costs, operating costs, and revenue streams were included in the NPV; the values are summarized in Table ES-3. The alternative economic evaluation is presented on Figure ES-1.

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Table ES-3. Summary of economic evaluation

	Alternative 0 Status Quo	Alternative 0A Modified Status Quo	Alternative 1 Merchant Facilities	Alternative 2 THP	Alternative 3 Thermal Dryer	Alternative 4 Lystek - Seasonal Operation	Alternative 5 Pyrolysis
Capital Costs ($ millions)							
Treatment/Storage Facility	$--	$80.7[a]	$--	$600.2	$199.0[b]	$78.0[a]	$354.1[b]
Solids screening	$--	$15.6	$15.6	$--[c]	$15.6	$15.6	$15.6
Total capital cost, $ millions (2021)	$--	$96.3	$15.6	$600.2	$214.6	$93.6	$369.7
Annual Operating Costs ($ Millions)							
Licensing fees present value (PV), $ millions (2021)	$0.0	$0.0	$0.0	$0.0	$0.0	$1.7	$0.0
Chemical PV, $ millions (2021)	$54.5	$55.4	$54.5	$120.0	$57.0	$55.3	$54.6
Labor PV, $ millions (2021)	$5.3	$37.1	$0.0	$63.6	$53.0	$26.5	$53.0
Natural gas PV, $ millions (2021)	$0.0	$0.0	$0.0	$64.3	$83.5	$0.0	$0.4
Biosolids management PV, $ millions (2021)	$231.1	$166.2	$350.7	$177.6	$19.9	$141.8	$7.2
Rehabilitation and Replacement (R&R) PV, $ millions (2021)	$0.0	$1.3[d]	$0.0	$87.8	$16.8	$6.8	$18.6
Screening PV, $ millions (2021)	$0.0	$10.5	$10.5	$0.0	$10.5	$10.5	$10.5
Total operating costs PV, $ millions (2021)	$290.9	$270.5	$415.7	$513.4	$240.8	$242.8	$144.3
Annual Revenue ($ Millions)							
Excess power generation (sale) PV, $ millions (2021)	($82.0)	($82.0)	($82.0)	($91.7)	($70.6)	($81.3)	($95.3)
Biosolids product sale PV, $ millions (2021)	$0	$0	$0	$0	($3.2)	$0	($1.7)
Annual revenue PV, $ millions (2021)	($82.0)	($82.0)	($82.0)	($91.7)	($73.8)	($81.3)	($97.0)
Annual Revenue Present Value, $ millions (2021)							
Net present value ($ millions)	$209	$285	$349	$1,022	$382	$255	$417

a. Offsite enclosed storage with odor control assumed. Four-month storage capacity provided. Location is assumed to be on District-owned property in Pinole. Cost for land is not included in the capital costs.
b. Alternative 3 includes 4 months of silo storage of pellets. Alternative 5 includes 4 months of biochar storage (bagged storage) based on manufacturer recommendation.
c. Sludge screening is included with the THP facility and is included in the THP facility costs.
d. R&R costs associated with equipment at the offsite storage location.

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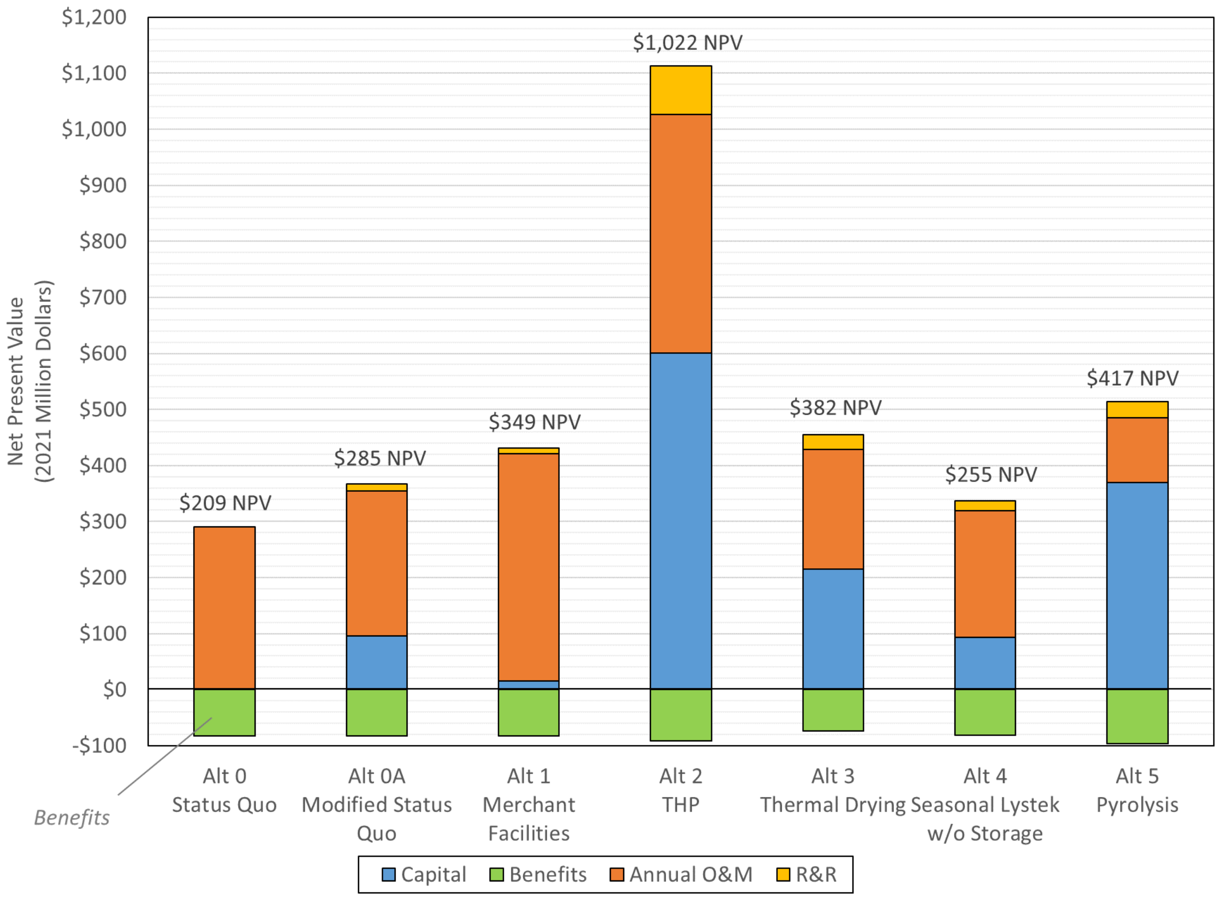

Figure ES-1. Net present value for each alternative

Figure ES-2 summarizes the results of the non-economic ranking of the five alternatives. Facility safety, flexibility to meet current/future regulations, and technology maturity/reliability are the three categories that have the highest weighting and thus have the largest impact on the overall score.

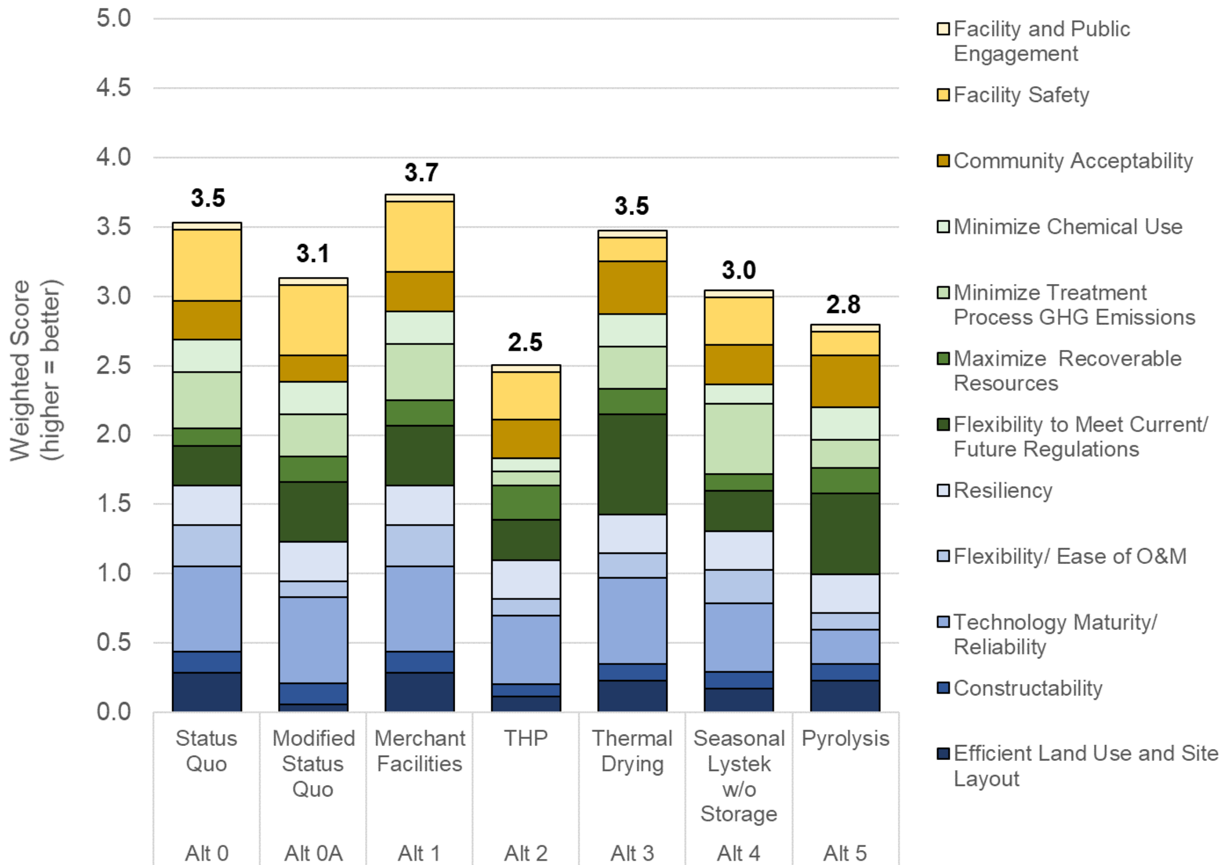

Figure ES-2. Non-economic score for each alternative

The following summarizes key conclusions from the alternatives evaluation:

- The status quo (Alternative 0) has a 3.5 non-economic score, and the NPV of the alternative is comparable to several other alternatives. The economics of this option are dependent on future biosolids management costs. It is recommended that the status quo alternative be carried forward into the development of the biosolids roadmap as a near-term option. As a long-term strategy, this alternative is dependent on the District having adequate merchant facility (or similar) options during the wet weather months.
- Offsite storage (modified status quo; Alternative 0A) has a 3.1 non-economic score. The NPV of this option is comparable to several other alternatives. Offsite storage would provide the District with a wet weather management strategy and would maximize biosolids land application. The main consideration with this alternative is finding a site that can be permitted for the storage facility. If a site can be secured and permitted, this alternative provides the District with near-term flexibility in biosolids management. For this reason, it is recommended that this alternative be carried forward into the development of the biosolids roadmap.

- THP (Alternative 2) has the lowest non-economic score and highest NPV. THP offers the advantages of higher-quality cake, increased digester capacity, and improved dewaterability; however, these benefits at the MWWTP are not great enough compared with the cost of the pre-digestion facility. For this reason, the THP alternative was eliminated from further consideration.
- Merchant facilities (Alternative 1) had the highest non-economic score, but one of the higher NPVs. While diversion to merchant facilities would likely remain in the District's biosolids management portfolio, 100% diversion to merchant facilities is not recommended as a long-term management option to carry forward. The success of this alternative is dependent on other entities building merchant facilities with adequate capacity for the future. This alternative would likely require the District to enter into long-term, year-round agreements to create and secure merchant facility capacity. Additionally, the alternative limits the District's ability to control management costs, capacity, and management practices. This alternative does represent a worst-case scenario with respect to biosolids management costs and, therefore, could be considered as an upper boundary condition to compare alternatives against in the development of the biosolids management roadmap.
- Lystek (Alternative 4) and pyrolysis (Alternative 5) have similar non-economic scores. The Lystek alternative has a slightly lower NPV due to the lower capital and operating costs. The alternative does not include costs for storage during wet weather months (offsite or onsite). A cost for offsite storage could be developed if this alternative were pursued, and the NPV of the Lystek alternative would increase. Currently, Lystek does not have established markets for end-uses other than land application; thus, the alternative does not offer new end-use markets; however, Lystek has worked with county regulators to extend the land application season based upon its certification as a fertilizer. The Lystek product has a lower solids content, which increases product volume (compared to status quo) and truck trips. It is recommended that the District continues to monitor Lystek as a post-digestion option to confirm project and operating costs as well as the development of new end-use markets.
- As noted above, pyrolysis (Alternative 5) has a similar non-economic score to Lystek but a slightly higher NPV than Lystek. Pyrolysis offers several advantages that include volume reduction and potential new end-use markets. The end-use market for the pyrolysis product (biochar) is being developed and the demand for the product is largely unknown at this time. The technology is considered to be emerging and does not have operational history at larger municipal wastewater treatment facilities. Due to the benefits that the alternative can provide, it is recommended that the District continue to monitor pyrolysis as a post-digestion option. The District should continue to monitor the installation, operational experience, and development of end-use markets, as well as the true project and operating costs.
- Thermal drying (Alternative 3) has one of the highest non-economic scores, and the NPV is similar to pyrolysis and Lystek. Thermal drying is an established technology with established end-use markets. The technology also offers the benefit of volume reduction. It is recommended that thermal drying be carried forward into the biosolids management roadmap as the placeholder, post-digestion technology.

Based on the conclusions from the alternatives evaluation, the following next steps are recommended for further refinement and/or integration into the biosolids management roadmap:

- The status quo (Alternative 0) should be carried forward into the development of the biosolids roadmap as a near-term option until the District develops alternative management strategies/facilities. As a long-term strategy, this alternative is dependent on the District having adequate merchant facility (or similar) options during the wet weather months.
- Offsite storage (modified status quo; Alternative 0A) would provide the District with a wet weather management strategy and would maximize biosolids land application. It is recommended that this alternative be further considered in the biosolids roadmap to confirm the timing and triggers for offsite storage.
- Merchant facilities (Alternative 2) should be further considered as an interim solution and the alternative carried forward into roadmap development. Pursuing this alternative involves the District taking initiative (including a long-term commitment of tonnage) to help advance the development of one or more merchant facilities in the Bay Area.
- Thermal dryer (Alternative 3) is the recommended placeholder, post-digestion technology. As the biosolids roadmap is developed, it is recommended that the timing and phasing of a thermal drying facility be considered. Because several other post-digestion technologies offer similar NPVs and non-economic scores, it is recommended that Lystek (Alternative 4) and pyrolysis (Alternative 5) continue to be monitored by the District. As the District further develops a post-digestion facility, these alternative technologies should be revisited to confirm that thermal drying is the optimal solution, both on an economic and non-economic basis.
- As the roadmap is developed, biogas production and prioritization should be confirmed and coordinated with the District’s development of the biogas utilization roadmap and the potential reduction in resource recovery waste streams as it relates to biogas production.

CHAPTER 1 - INTRODUCTION

The goal of the East Bay Municipal Utility District's (District) Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan Project (Master Plan) is to provide a 30-year roadmap for the MWWTP that addresses future regulations, aging infrastructure, capacity constraints, and climate change. This report focuses on biosolids management alternatives for the 30-year planning horizon and identifies capital improvement program (CIP) projects to provide the District with a cost-effective and reliable biosolids management program that is adaptable to future regulations.

The purpose of this report is to describe the biosolids management alternatives that were screened, developed, and identified for incorporation into the Master Plan.

This report is organized as follows:

- Executive Summary
- Chapter 1: Introduction
- Chapter 2: Background
- Chapter 3: Biosolids Management Regulations and Trends
- Chapter 4: Screening the "Universe of Alternatives"
- Chapter 5: Alternatives Development and Evaluation
- Chapter 6: Conclusions and Next Steps
- Chapter 7: References

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CHAPTER 2 - BACKGROUND

A complete description of the District's treatment facilities is included in the Wastewater System Overview report (EBMUD, 2019). The solids system includes waste activated sludge (WAS) thickening, anaerobic digestion, and centrifuge dewatering. The anaerobic digesters operate at 125 degrees Fahrenheit (°F) with a target hydraulic residence time of 15 days. There are eight first-stage digesters and three second-stage digesters. Digested solids are pumped from the second-stage digesters to the Dewatering Facility.

The District operates a resource recovery (R2) program that accepts trucked wastes at three locations at the MWWTP. Low-strength trucked waste is accepted at the plant headworks; high-strength trucked waste is discharged to one of two receiving stations and pumped to the solids blend tank, where it is combined with primary sludge and thickened WAS and pumped to the anaerobic digesters. Class B biosolids cake is produced and is beneficially used offsite. During the dry weather season, the majority of biosolids are used as soil amendment at land application sites in Merced County. During the wet weather season, biosolids are used as alternative daily cover (ADC) at nearby landfills in Alameda and Solano counties, taken for compost production in Merced County, or land applied at a wet weather site in Sacramento County. The exact diversion of biosolids to each end-use varies each year. In 2018, 77% of biosolids were land applied, 10% were used as ADC, and 13% were processed at the offsite compost facility; the 2018 annual management cost was approximately $3.4 million. In 2019, costs were approximately $3.9 million; the higher cost was due to both a slightly higher volume of solids generated and a longer wet weather season, the latter of which triggered more costly end-uses.

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CHAPTER 3 - BIOSOLIDS MANAGEMENT REGULATIONS AND TRENDS

This section provides an overview of current and future regulations related to the beneficial use of biosolids and the resulting biosolids management cost trends.

3.1 Land Application

The primary set of regulations governing the beneficial use (and land application) of biosolids exists in Title 40, Part 503 of the Code of Federal Regulations, often referred to as "the 503 Rule." These regulations contain reporting requirements, mandatory management practices, limits on heavy metals, vector attraction reduction requirements, and pathogen reduction requirements. Currently, the 503 Rule does not include regulations on contaminants of emerging concern.

Local county ordinances and permitting requirements have had the impact of restricting land application in certain areas of California, including San Joaquin and Stanislaus counties, both of which have substantial agricultural acreage. There is ongoing effort by the California Association of Sanitation Agencies (CASA) to modify these restrictions to be consistent with statewide goals around organics recycling, but no changes have been realized at this time. In Northern California, local county ordinances restrict land application during or after rain events, which typically limits land application from April through October. In addition, Solano, Sonoma, and Merced counties all place seasonal restrictions on biosolids land application, prohibiting land application during winter months. The ordinance in Solano County contains additional restrictions to address environmental concerns, such as land application in the secondary marsh areas, as well as public concerns associated with odors and traffic generated by land application on weekends. A recent study was performed for the Bay Area Biosolids Coalition (BABC) to assess relative land application capacity in neighboring counties based on data from the California Census of Agriculture. The study determined that even with restrictions in San Joaquin and Stanislaus counties there is adequate capacity for BABC agencies to continue to land apply biosolids during dry weather months (Carollo, 2019). Thus, land application of Class B biosolids is a reliable outlet during dry weather periods.

In late 2020, the State Water Resources Control Board (SWRCB) issued a sampling and analysis plan for the Bay Area publicly owned treatment works (POTW) to sample and analyze influent, effluent, and biosolids on a quarterly basis for per and polyfluoroalkyl substances (PFAS). The SWRCB also announced its intent to set regulatory standards for levels of some PFAS in drinking water. While this does not immediately impact biosolids land application, it is possible that standards in groundwater could be used to set limits for specific PFAS in biosolids. The United States Environmental Protection Agency (EPA) has begun the risk assessment for two of the most prevalent and best-studied PFAS – perfluorooctanesulfonic acid [PFOS] and perfluorooctanoic acid [PFOA] in biosolids. It is likely that the SWRCB's regulatory framework for PFAS will be in place prior to adoption of standards on the federal level. At the state level, the implications for biosolids are expected to become evident within the next 3 to 5 years. The impact on biosolids programs is an unknown but is most likely to create issues for those POTWs accepting industrial wastes from known PFAS generators (e.g., landfill leachate, carpet manufacturers, military installations, and fire-fighting training stations). At this time, potential PFAS regulations related to biosolids are assumed to result in reduced land application rates, such that more acreage and longer hauling routes may be required.

3.2 Landfill/Alternative Daily Cover

During winter months, POTWs in Northern California have largely relied on beneficial use of biosolids at landfills for ADC; however, on the state level, a significant shift is underway related to Senate Bill (SB) 1383, which sets a statewide target related to diversion of organics from landfill disposal to beneficial use. Biosolids are included in the State's definition of organics and would comprise part of the total quantity of organics to be diverted, in addition to food waste and green waste. As compared to 2014 levels, SB 1383 sets a target of 50% diversion of organics from landfill disposal to beneficial use by 2020, and 75% diversion by 2025. Under SB 1383, ADC will no longer be considered a beneficial use. Compliance with SB 1383 is initially going to be measured at the state level. If CalRecycle determines that the organic diversion targets are not being met at the state level, enforcement action may be taken on non-compliant entities and/or jurisdictions. The implementing regulations associated with SB 1383 are final, and corresponding enforcement begins on January 1, 2022.

In Northern California, SB 1383 has already had impacts on the ability of POTWs to divert biosolids to landfills as ADC. The lack of availability of common ADC blend materials, (i.e., yard and food waste) and the removal of the ADC credit, mean that landfills have a reduced ability to use biosolids as ADC. Biosolids used at landfills for slope stabilization or erosion control will continue to be considered beneficial use, but the demand/capacity for this use is expected to be reduced. Recent incidents related to landfill slope failure have been attributed to acceptance of high levels of high-moisture wastes, such as biosolids. As a result, many large landfill companies have set internal limits on the relative volume of high-moisture wastes that can be received daily. Within the Bay Area, this factor, in addition to SB 1383, has significantly impacted the ability, capacity, and incentives of landfills to accept biosolids.

The resulting impact is that the Bay Area has a capacity limitation for biosolids management options during wet weather months (typically defined as October to April), when land application is generally more restricted. Additional market pressure will exist when the San Jose/Santa Clara Water Reclamation Facility (WRF), the largest generator of biosolids in the Bay Area, shifts away from current practices (onsite air drying and diversion to Newby Island landfill) and enters the biosolids management market. Given the volume of biosolids generated at the WRF, this shift will further add pressure on wet weather outlets. As many utilities have traditionally relied on landfills for wet weather management, new wet weather capacity is needed in the Bay Area.

3.3 Biosolids Management Cost Trends

The regulatory and market shifts described above have direct impacts on the District's ability to manage its biosolids and the costs of these management options. In addition to the future regulatory shifts noted above, there is an additional cost pressure related to biosolids hauling. In December 2015, the Federal Motor Carrier Safety Administration published the Electronic Logging Device (ELD or e-log) rule, which requires truck drivers to maintain an electronic log of the time spent driving. ELDs facilitate compliance with rules limiting a truck driver's hours of service. Its impact can be noted in biosolids routes that are more distant (e.g., Merced), as a provider may now need more drivers to complete the same number of deliveries.[1]

The cost of the District's biosolids management program historically was relatively stable until 2017. In 2017 costs were observed to increase primarily due to limited wet weather management options, which drove prices up. With the District's current contract, wet weather biosolids management has a unit cost of $63.80/wet ton. This cost includes landfill ADC, land application during the wet weather season, or diversion to an offsite compost facility (also referred to as a merchant facility). The District's dry weather land application costs have generally remained stable with a lower 2020 unit cost of $33.50/wet ton. Figures 3-1 through Figure 3-3 illustrate land application, merchant facility, and landfill/ADC management costs from 2016 through 2020. As noted on the figures, the trends and regulations noted above have resulted in higher management costs, and based upon bid results from other Bay Area utilities it is expected that costs will increase significantly when the District goes to rebid its contract in 2021. Merchant facilities, which can provide additional wet weather capacity, generally employ more expensive technologies and have a higher unit cost. Recent bids for wet weather usage of these sites have reflected an increase in cost based on a higher demand for these services (Figure 3-2). These data were used to help develop curves that predict increases in cost of various services, as described subsequently in Sections 3.3.1 through 3.3.4. The curves were used as a planning aid to articulate risks associated with potential cost increases in the three different management outlets: land application, merchant facilities, and landfill/ADC (curves presented in Workshop 2; materials and meeting minutes are provided as Appendix A). Biosolids markets in the Bay Area are currently very volatile, and as such, actual market conditions may diverge from these predictions.

[1] Under the federal Hours of Service rule, truckers may drive a maximum of 11 hours in a consecutive window of 14 hours, after which they must take 10 consecutive hours off duty.

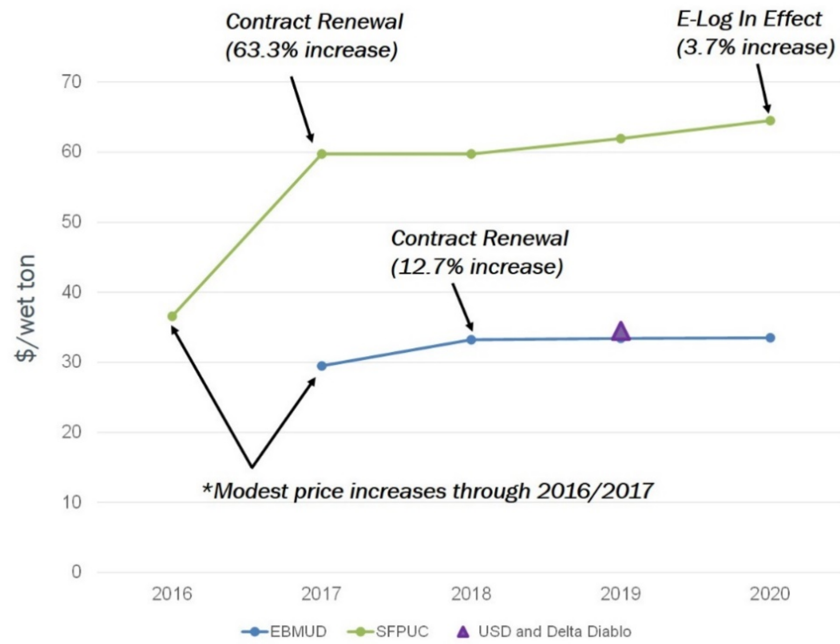

Figure 3-1. Bay Area land application price trends

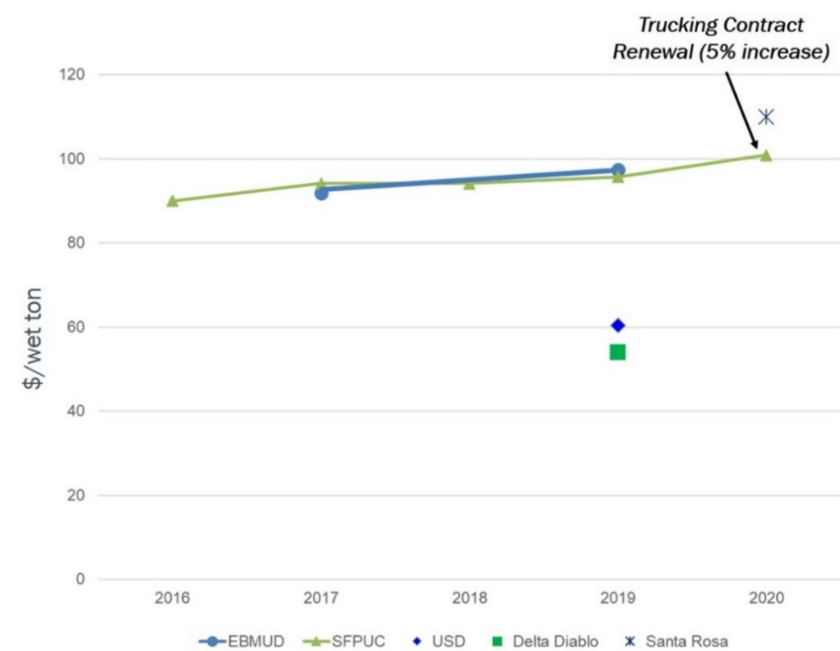

Figure 3-2. Bay Area merchant facility price trends

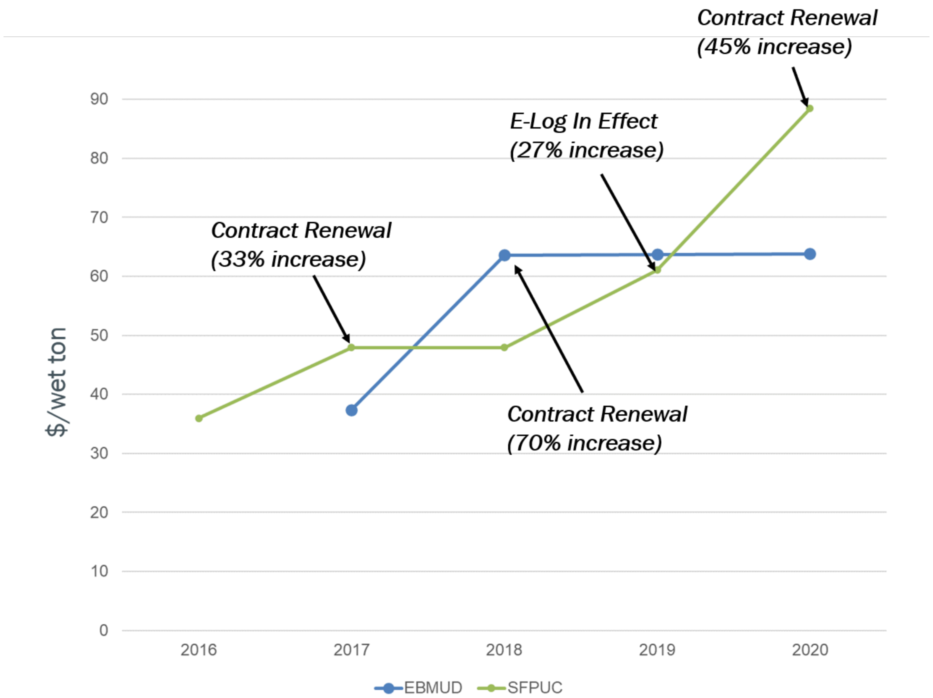

Figure 3-3. Bay Area landfill/ADC price trends

3.3.1 Land Application Cost Projection

Based on the recent cost trends, it is reasonable to expect an increase in cost now, due to increased biosolids being managed in land application and merchant facilities; however, as noted in the C30 Market Assessment report (Brown and Caldwell, 2021), sufficient acreage exists for management of Bay Area biosolids during the dry weather season. As shown on Figure 3-4, a cost increase is expected in 2021 when the District renews its biosolids management contract. After the near-term increase in 2021, and based upon currently available information, land application costs can reasonably be expected to increase with a predicted consumer price index (CPI) of 2.5%.

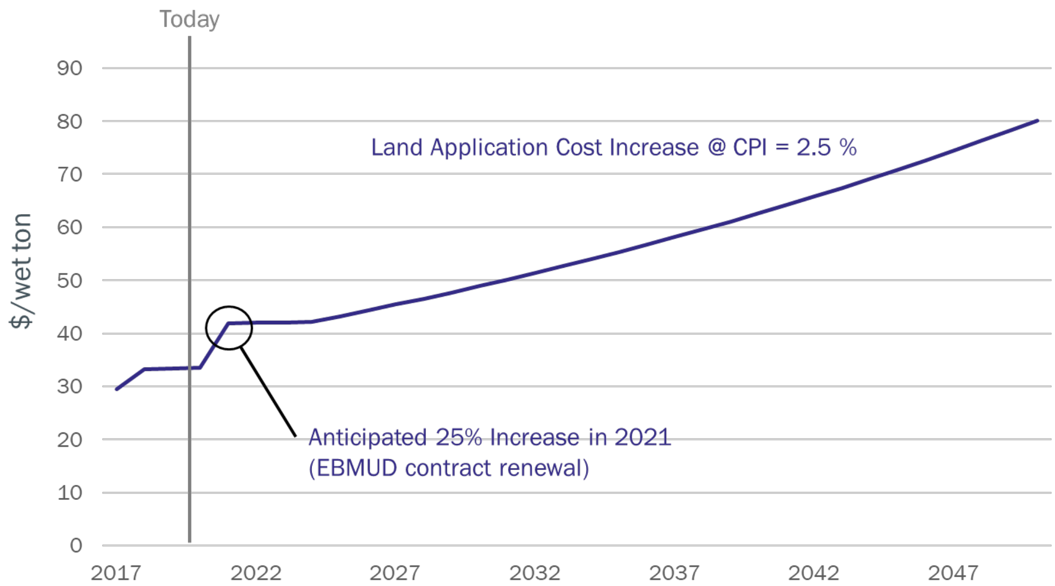

Figure 3-4. Land application unit cost projection

3.3.2 Merchant Facility Cost Projection

Merchant facilities in the Bay Area are expected to be capacity-limited in the near term. For this reason, recent bids have demonstrated a sharp increase in merchant facility pricing. As noted earlier, new facilities are expected to be built to manage wet weather tonnage from the Bay Area, provided that long-term tonnage commitments from utilities can be secured. In addition to employing more complex technologies, these facilities are likely to have more stringent air quality control requirements, as well as other requirements related to odors that could impact pricing. For example, an enclosed compost facility would be expected to be significantly more expensive than Synagro's open-air windrow facility in Merced County. At the same time, vendors are aware that they need to offer competitive rates, and thus, the expected increase is anticipated to be greater than CPI until more capacity can be brought online. For planning purposes (i.e., to facilitate decision making, to articulate cost-based risks), cost trends were estimated for merchant facilities in the Bay Area, provided as Figure 3-5; in the near-term, a 6% increase is expected based on the most recent publicly available bids for such services in the Bay Area. By 2025, new facilities are expected to be in planning/implementation stages, decreasing competition for merchant capacity and stabilizing pricing to increase with CPI more predictably.

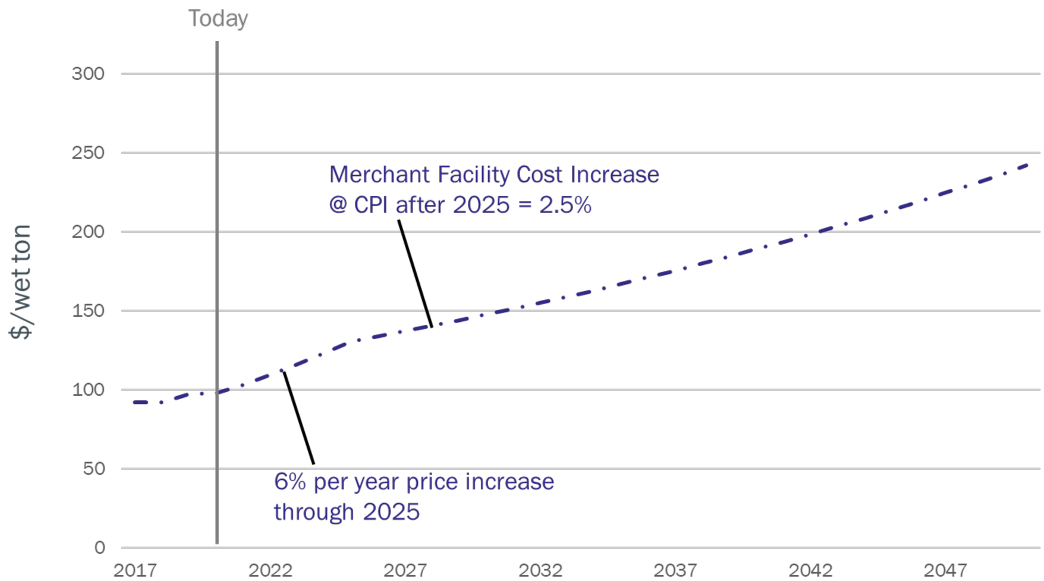

Figure 3-5. Merchant facility unit cost projections

3.3.3 Landfill /ADC Cost Projection

Until implementation of SB 1383 stabilizes (currently, the last regulatory milestone relates to 75% diversion of organics by 2025) and new wet weather biosolids management capacity is created, costs should be expected to increase at a rate that is significantly greater than the CPI, a more typical metric for cost increases. Given the complexity of permitting new facilities in California, it is expected that facilities capable of managing the Bay Area's wet weather biosolids tonnage could take up to 10 years to come online. Based upon recent bids for landfill services in the Bay Area shown previously, an estimated cost curve was developed (Figure 3-6). As the District appears to be paying under market price for landfill services currently, the estimated cost curve predicts a 30% increase upon contract renewal in 2021 and a second 30% increase upon planned renewals in 2025 and 2027. After this point, improved regulatory stability and new management facilities would relieve the pricing pressures from this outlet, and costs would be expected to increase with the CPI. It should be noted that while Figure 3-6 presents the expected cost trend, this outlet as described above is considered unreliable due to capacity constraints and regulations that de-incentivize biosolids beneficial use at landfills.

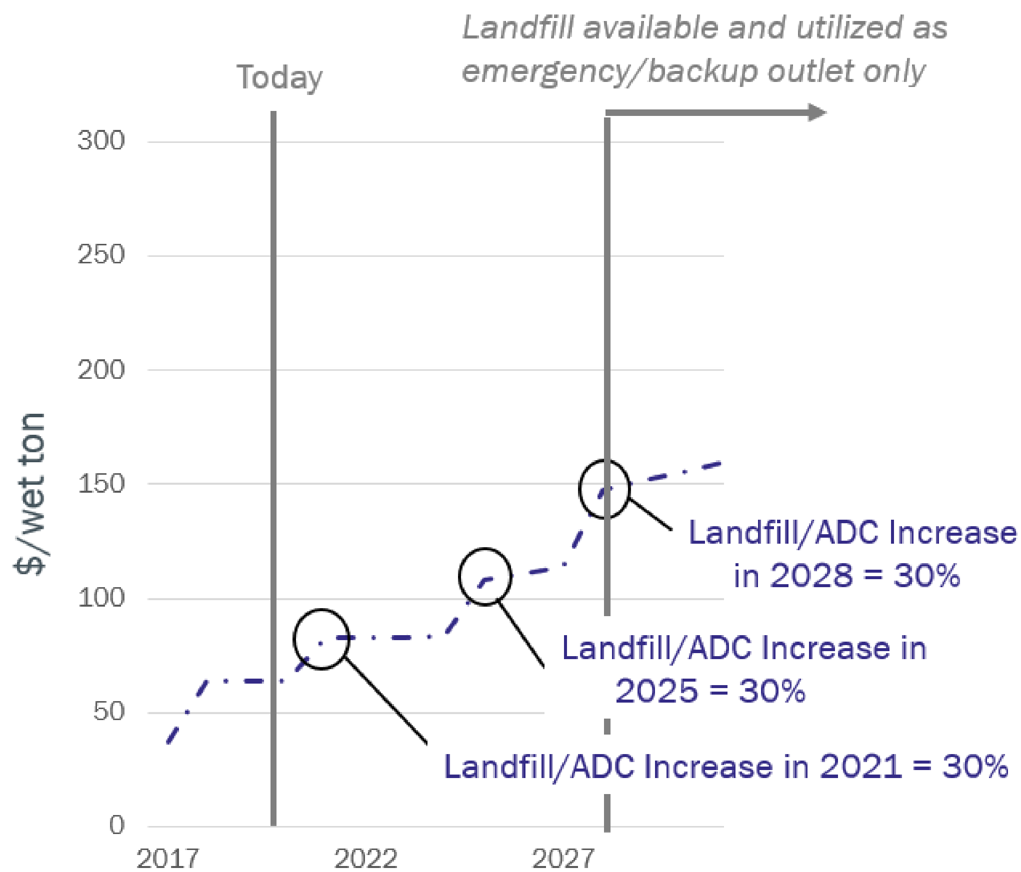

Figure 3-6. Landfill/ADC unit cost projections

3.4 Biosolids Management Endpoints

The following were considered in developing regulatory endpoints for the development of the Master Plan alternatives:

- **Land application:** Currently, there are no concerns with land application capacity in Northern California, and CASA continues to make efforts to unlock further acreage in counties that currently have land application bans. Therefore, Class B land application is considered secure within the timeline of the Master Plan. For the purposes of land application as an end-use, there is no direct driver to develop a Class A product. The caveat to this conclusion is that, as noted below, there is uncertainty around the impact of developing PFAS regulations, which could limit land application rates or trigger the need for out-of-state land application, both of which would likely cause land application costs to increase significantly.

- **ADC/Landfill Disposal:** ADC and landfill disposal are not considered reliable outlets in the future based on landfill limits on acceptance of high-moisture wastes and regulations associated with SB 1383. While the District may wish to continue to use landfills as a backup outlet, it should be noted that the cost of using this outlet will be high, and available capacity will not be reliable at any given time.
- **Class A product**: As noted previously, there is no clear need to develop a Class A product for land application; however, developing a Class A product could provide the following benefits: program diversification, potential reduction in transportation costs, and expansion of beneficial use markets that are consistent with statewide goals (e.g., Healthy Soils Initiative, Natural and Working Lands Implementation Plan). Drying technologies provide the benefit of volume reduction in addition to generating a Class A product, which would give the District less volume to manage, and thus more flexibility.
- **Future PFAS Regulations:** While considerable uncertainty exists as to impacts of developing regulations on land application, regulatory impacts at the state level should become evident within the next 3 to 5 years. At the federal level, those would likely be promulgated within the next 5 years if regulations arise from the current risk assessment effort. Should biosolids be regulated at either the state or federal level, the concentration of specific PFAS in the District's biosolids could be used to modulate biosolids land application rates. This could range from the following: reduced application rates, a trigger to land apply biosolids out of state, or an effective ban on land application. Any of these three outcomes would have significant cost implications for the District.

Based on the above considerations, biosolids management alternatives were developed based on the following regulatory endpoints:

- Production of a marketable Class A product: Marketable products (e.g., compost, soil blends, or thermally dried products) would allow the District to move beyond the outlets it has traditionally used and help reduce risk.
- Increased wet weather beneficial use options: Land application is limited in Northern California during the winter months. Proactive development of wet weather options will help stabilize costs and minimize risk over the long term.
- Pathway to address regulatory uncertainty around PFAS: The outcome of current efforts to regulate PFAS and its impact on biosolids management is an unknown at this time. Thus, long term plans will address potential impacts to the program if land application should become limited in the future.

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CHAPTER 4 - SCREENING THE "UNIVERSE OF ALTERNATIVES"

A comprehensive list of biosolids technologies (as detailed in Appendix B) was developed with the District during a workshop conducted on September 19, 2019 (workshop materials and meeting minutes are provided as Appendix C). The comprehensive list of technologies is referred to as the "universe of alternatives." The technologies were screened using pass/fail criteria that were developed in a series of workshops with the District. Screening criteria is summarized in Table 4-1. The screening criteria and evaluation process are described in detail in C50 Evaluation Criteria and Process Report (Carollo, 2021).

Table 4-1. Screening criteria

Screening Criteria	Description for Pass/Fail	Metric[a]
Ability to meet regulations	Complies with near-term biosolids regulations, supports beneficial use, and can be adapted to meet anticipated regulations.	Pass/Fail
Technology maturity and risk (at this size)[b]	Proposed technology/approach has at least one installation with a capacity of 20 million gallons per day (mgd) (14 dry tons per day) or greater, with at least one year of successful operation (within the last 10 years) at 90% capacity.	Pass/Fail
Ease of permitting	Technology has been permitted at a wastewater treatment plant (WWTP).	Pass/Fail
Site constraints	Structures, equipment, etc., fit within the existing WWTP boundaries.	Pass/Fail
Independent operations	Facilities can be fully operated by District Staff (i.e., contract operations by independent entities is not required).	Pass/Fail
End-use diversification[c]	Provides new end-use markets beyond status quo (Class B land application and landfill ADC)	Pass/Fail

a. The screening criteria were applied on a pass/fail basis – the alternative either meets the criteria (Pass) or it does not (Fail). Alternatives must meet all criteria to be considered viable and evaluated further.

b. To facilitate screening, technologies were grouped into three categories of technology maturity: embryonic, emerging, and established. Technology status is defined in Chapter 5.

c. Criterion was considered for biosolids alternatives to provide additional differentiation of alternatives, as needed.

Technology status was defined as follows using industry-accepted 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.

- **Emerging:** Technology categorized as emerging is commercially viable and has been proven at full scale in one or more installations. Emerging technologies have a shorter track record than established technologies (typically less than 5 years), and operations and maintenance (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. The "universe of alternatives" identified during the September 19, 2019 workshop were categorized based on the location in the treatment process train (i.e., pre-digestion, digestion, and post-digestion) and screened assuming 2050 medium-growth flow and load projections (Appendix E). For the screening analysis, high-strength waste (HSW) streams were not included in the solids projections; this assumption was made to avoid eliminating a technology due to HSW contributions. The screening was performed with District Staff and presented at a workshop on December 19, 2019. The detailed screening results are provided as Appendix C and a summary of results is provided as Table 4-2.

The "universe of alternatives" identified during the September 19, 2019 workshop also included two management strategies listed below:

- **Merchant Facilities for Offsite Processing of Biosolids:** consists of diversion of biosolids to merchant facilities for additional post-digestion processing and beneficial use. This management strategy was developed and evaluated as Alternative 1 (described in Chapter 5).
- **Offsite Storage of Biosolids:** consists of offsite storage of biosolids cake during winter (wet weather) months and land application during dry weather months. This management strategy was considered as the Modified Status Quo (Alternative 0A) and is described in more detail in Chapter 5.

These options were considered during the alternatives evaluation that is described in Chapter 5. Because these options were considered to be strategies and not technologies, they were not included in the technology screening analysis.

Table 4-2. "Universe of Alternatives" screening – Summary of Results[a]

Technology	Ability to Meet Regulations	Technology Maturity and Risk	Ease of Permitting	Site Constraint	Indep Operation	End-Use Diversification	Selected for Further Development
Pre-Digestion							
THP[b]	Pass	Pass	Pass	Pass	Pass	Pass[b]	Yes
Digestion							
Temperature-phased anaerobic digestion	Pass	Pass	Pass	Pass	Pass	Fail	No
Thermophilic batch anaerobic digestion	Pass	Pass	Pass	Pass	Pass	Fail	No
High-solids anaerobic digestion (8% – 10%)	Pass	Pass	Pass	Pass	Pass	Fail	No
Post-Digestion							
Thermal drying	Pass	Pass[c]	Pass	Pass	Pass	Pass	Yes
Open composting	Pass	Pass	Fail	Pass	Pass	Pass	No
Enclosed composting	Pass	Pass	Pass	Pass	Pass	Pass	No[d]
Thermal chemical hydrolysis (Lystek)	Pass	Pass[c]	Pass	Pass	Pass	Fail (See Note) [e]	Yes
Incineration	Pass	Pass	Fail	Pass	Pass	Pass	No
Drying beds	Pass	Pass	Pass	Fail	Pass	Fail	No
Greenhouse-style solar drying	Pass	Pass	Pass	Pass	Pass	Fail	No
Pyrolysis	Pass	Fail (See Note) [f]	Pass	Pass	Pass	Pass	Yes
Gasification	Pass	Fail	Pass	Pass	Pass	NA	No

a. Refer to Appendix C for detailed screening results.
b. The market assessment identified potential for THP product to be used at soil blending facilities; however, it is expected that the primary end-use for the THP cake will be land application.
c. A list of thermal drying and Lystek installations are provided for reference, as part of Appendix D.
d. Enclosed composting was not carried forward due to the large land requirements, increased product volume, and limited market value as further described below.
e. The current end-use for the Lystek product is limited to land application. Lystek is working to develop alternative markets/end-uses; however, at this time they do not exist. Lystek has registered the product as a fertilizer and has extended the land application season within the Bay Area. Due to Lystek's efforts to develop new end-use markets and the expanded land application season, the District chose to retain this technology.
f. While this technology is emerging, a successful installation in the Bay Area, along with the potential benefits associated with significant volume reduction and carbon sequestration led the District to retain this technology. A list of pyrolysis installations are presented in Appendix D.

The digestion technologies listed in Table 4-2 would produce a Class A biosolids cake. Although the Class A anaerobic digestion technologies fit on the site and are established, the technologies were eliminated from further consideration because there is no anticipated regulatory driver that would require a Class A cake for land application. Furthermore, Class A cake does not establish new beneficial use markets.

Greenhouse-style solar drying was not carried forward because the product has limited value or marketability in new end-use markets. This is primarily due to the quality of the product, which tends to be dusty and have a non-uniform size.

While composting is an established technology, it was eliminated from further consideration for the following reasons:

- **Large footprint/land requirement:** The land required for an enclosed compost facility is estimated at 12.8 acres, which is significantly greater than other alternative technologies.
- **Increased product volume:** The composting process requires the addition of a bulking agent and, therefore, the final product volume is typically more than the original biosolids volume.
- **Limited market value:** The market assessment identified that the value of a biosolids-derived compost is expected to be low in future years. This is due to the expectation that the market will be flooded with compost products, most of which will be non-biosolids derived and have a higher market value and/or a competitive advantage.

Based on the results of the screening, four technologies were carried forward for additional development for the reasons noted below:

- **THP:** may provide an opportunity to enter new end-use markets and produces a higher-quality cake.
- **Thermal Drying:** produces a pellet that can be used in new end-use markets; technology has a compact footprint and reduces volume of the end-product (compared to status quo).
- **Chemical thermal hydrolysis (Lystek):** has a small footprint and the product can be land applied for a longer duration/season. In the future, the product may be used in other beneficial use markets.
- **Pyrolysis:** Although the technology is emerging, it offers benefits of having a smaller footprint and reduced volume of final product, and the product may be used in new beneficial use markets.

CHAPTER 5 - ALTERNATIVES DEVELOPMENT AND EVALUATION

The technologies that passed the screening process described in Chapter 4 were developed and evaluated with a status quo alternative and the two biosolids management strategies (i.e., diversion to merchant facilities and offsite cake storage) that were identified during the brainstorming session as follows:

- Alternative 0 – Status Quo
- Alternative 0A – Status Quo with Offsite Cake Storage (herein referred to as Modified Status Quo)
- Alternative 1 – Post-Digestion, Merchant Facilities
- Alternative 2 – Pre-Digestion, THP
- Alternative 3 – Post-Digestion, Thermal Drying
- Alternative 4 – Post-Digestion, Lystek
- Alternative 5 – Post-Digestion, Pyrolysis

This section describes the development and evaluation of the alternatives.

5.1 Planning Level Criteria

The following section presents the planning level criteria used with alternatives development.

5.1.1 Flows and Loads

The biosolids management alternatives were developed for 2050 flow and load conditions, assuming medium population growth and medium R2 growth. The plant-wide process model was used to develop average dry weather (ADW) solids system flows and loads. The solids system peaking factors (developed as part of the C70 Existing Plant Capacity report, 2021) were applied so that equipment could be sized for maximum month and maximum week conditions. The digester feed (or blend tank sludge), and digested sludge loads used for the analysis are presented as Table 5-1 for the 2050 ADW conditions and assume that the high-purity oxygen activated sludge system is operated similar to current operation. This was determined to be a conservative assumption because WAS flows and loads are higher compared to those under a future nutrient removal scenario. Appendix E provides the maximum month and maximum week solids system flows and loads.

Table 5-1. Alternatives development solids system flows and loads (year 2050)

Parameter	Units	2050 Projection
Blend tank sludge (BSL) to Digester		
BSL flow	mgd	1.0
BSL total solids (TS) concentration	%	4.6
BSL TS loading	lb TS/d	380,000
Digested solids (Digester effluent from second-stage digester)		
Digested solids flow	mgd	1.0
Digested solids TS concentration	%	2.5
Digested solids TS loading	lb TS/d	203,000
Dewatered cake		
Cake flow	mgd	0.07
Cake solids TS concentration	%	24
Cake solids TS load[a]	lb TS/d	141,000

a. The model predicted solids cake was multiplied by a correction factor of 0.76 to account for the model overprediction (refer to C60 Plant-Wide Process Model Report, 2021).
mgd = million gallons per day
lb TS/d = pounds of total solids per day

5.1.2 Biogas Utilization and Plant Energy Demands

Based on the increased influent loads through the planning horizon, biogas production and plant energy demands will increase through year 2050. For the purposes of alternatives development, the plant energy demand for all alternatives was increased proportional to influent loads, and the average plant energy demand was estimated to be 6.4 megawatts (MW) in 2050. New energy demands related to the biosolids technologies were added to the plant energy demand; plant energy demands were not added for other upgrades, such as mainstream nutrient removal, sidestream treatment, ultraviolet disinfection, etc., because these demands would be common to all alternatives and would not impact the evaluation process.

For all alternatives, biogas utilization was prioritized to maximize energy production and to heat the digesters. Thus, biogas was diverted first to the District's existing cogeneration system (turbine and internal combustion engines). The firm and total capacity of the cogeneration system is approximately 9 MW and 11 MW, respectively (firm capacity assumes one turbine and two internal combustion engines in operation, and total capacity assumes one turbine and three internal combustion engines in operation). Biogas demands at firm and total capacity are approximately 2,400 and 3,100 standard cubic feet per minute (scfm), respectively. Based on discussions with District Staff, the alternatives were developed assuming the cogeneration system is not increased in the future due to anticipated air permitting challenges and assuming the total capacity of the cogeneration system is available (i.e., 11 MW of power production and 3,100 scfm of biogas utilization). After meeting the demands of the cogeneration system, excess biogas was directed to new unit processes (e.g., thermal drying) or flared. Power generated onsite in excess of plant demands was assumed to be sold at $0.058 per kilowatt hour (kWh).

5.1.3 Siting

New biosolids facilities were assumed to be located to the west of the existing anaerobic digesters, as shown on Figure 5-1. The location was selected because it is currently open land that is near the digesters. The location is also close to Engineer's Road, such that biosolids truck traffic inside the plant is minimized. This location was refined as the roadmap was developed and was incorporated with siting of new dewatering, sidestream, and mainstream nutrient removal facilities.

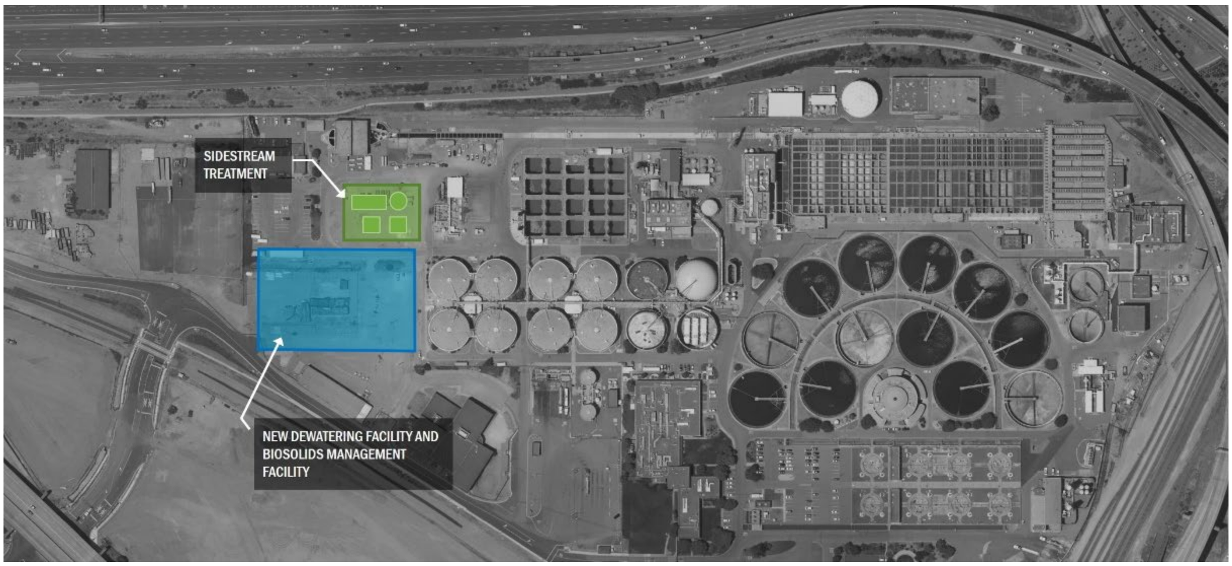

Figure 5-1. Site location for new biosolids management facility

5.2 Alternative 0 – Status Quo

Under this alternative, the District would continue to produce a Class B biosolids cake (24% solids). The Class B cake would be land applied during the dry weather season. During the wet weather season, the biosolids cake would be diverted to a merchant facility (i.e., storage, compost, Lystek, or wet season land application site). Landfill/ADC was assumed to be an unreliable outlet in the future due to SB 1383 and, therefore, was not considered a reliable biosolids management option after 2022. A 50% split between land application and merchant facilities was assumed from 2023 through 2050 (Figure 5-2), and management costs were escalated using the projections presented in Section 3.3. The resulting aggregate biosolids management unit cost in 2025 is $87/wet ton, and in 2050 is $161/wet ton. Figure 5-2 provides a schematic of the alternative for 2050 conditions. In 2050, an average of 15 biosolids trucks would leave the plant each day. Table 5-2 summarizes the assumptions for the Status Quo alternative.

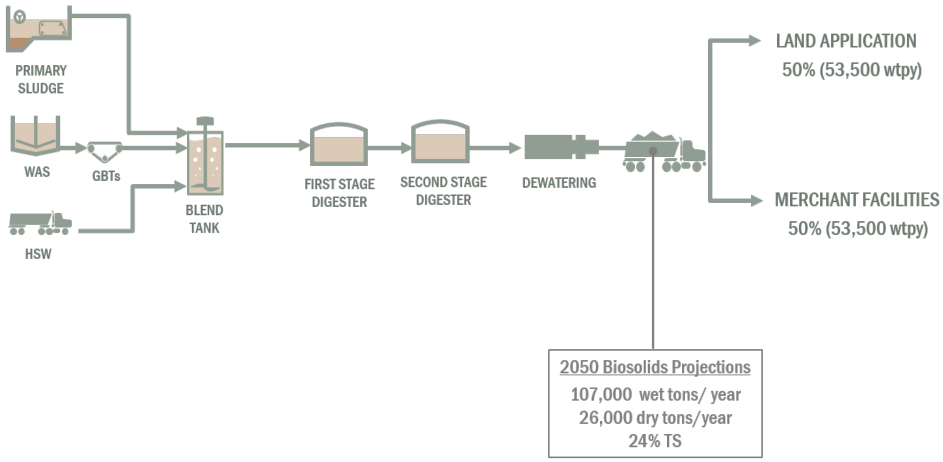

Figure 5-2. Status quo (Alternative 0) schematic

**Solids system is only shown for clarity.*

Table 5-2. Status Quo (Alternative 0) planning criteria

Parameter	2050 Conditions
Biosolids end-use	
Land application, wet tons per year (wtpy)	53,500
Merchant facilities, wtpy	53,500
Solids content, % TS	24
Number of biosolids trucks, trucks/day[a]	15
Total land requirements	--
Additional full-time equivalent employees (FTE)	--
Biogas production and usage	
Average biogas production rate, scfm[b]	3,200
Biogas diverted to power generation station (PGS), scfm	3,050
Biogas used with boiler, scfm	0
Biogas flared, scfm	150
Natural gas purchased, therms/day	--

a. Assumes trucks haul 20 wet tons per load.
b. Assumes 26 standard cubic feet (scf) of biogas per pound volatile solids destroyed.

The Status Quo (Alternative 0) does not require new facilities to be constructed at the MWWTP. Because this alternative does not add new unit processes at the MWWTP, no additional FTEs were assumed. The projected average plant energy demand in 2050 was estimated to be 6.4 MW, which does not include additional energy demands associated with sidestream or mainstream nutrient removal. Excess biogas was assumed to be flared (approximately 150 scfm flared in 2050).

5.3 Alternative 0A – Modified Status Quo

Alternative 0A is similar to the Status Quo (Alternative 0); however, cake storage would be constructed and used to manage biosolids during the wet weather months. Due to the land required for cake storage (ranging from 2 to 4 acres), the storage facility was assumed to be located at an offsite location. Figure 5-3 presents a schematic for Alternative 0A: Modified Status Quo.

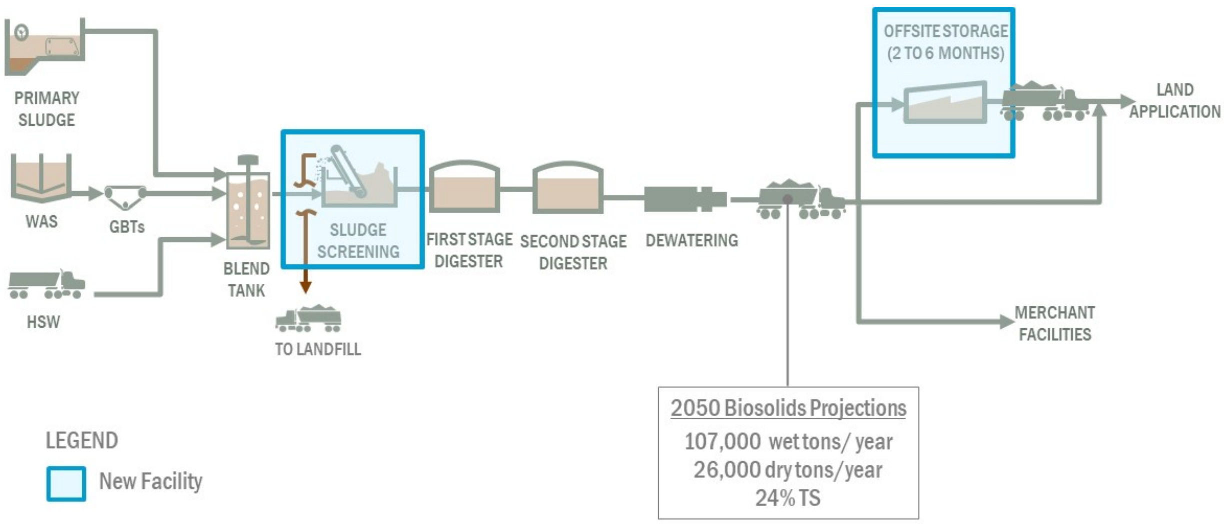

Figure 5-3. Modified status quo – offsite storage (Alternative 0A) schematic

**Solids system is only shown for clarity.*

Of note, this alternative assumes that sludge screening is constructed at the MWWTP to improve the quality of the biosolids. This was a recommendation that was raised in the December 19, 2019 workshop by District Staff who have noted that at times biosolids cake can contain visible contaminants/detritus that could impact acceptance at merchant facilities. To date this has not been an issue; however, the second-stage digesters are currently not mixed, such that detritus likely settles out in the digesters. As part of the Digester Phase 3 Upgrades that are in construction now, second-stage digester mixing is being constructed. The mixing may increase detritus in the cake and, therefore, may become a more significant issue in the future. By providing screening, the District would have more flexibility in the merchant facilities and end-uses it pursues, even under this alternative. Based on the District's observations and concerns, screening is assumed upstream of the first-stage digesters for this and all subsequent alternatives. This is assumed to consist of screening of the blend tank contents (primary sludge, thickened WAS, and HSW streams). It should be noted that the District is also considering screening between the first-stage and second-stage digesters; however, the impact of struvite precipitation on screen blinding should be considered at this location. When screening is advanced into the planning and design phases, the exact location of the facility should be confirmed. Additionally, the District should also confirm the benefits of screening primary sludge and WAS or if screening is only needed for HSW streams. For the purposes of alternative development, sludge screening downstream of the blend tank was assumed; the screening facility was assumed to be enclosed in a building with odor control provided. The capital cost of the sludge screening facility was estimated to be $16 million.

For this Alternative cake would be hauled from the MWWTP during wet weather months to the offsite storage facility where it would be stored until it could be land applied. As noted below, the alternative includes some diversion to merchant facilities to maintain a diverse biosolids management portfolio. Table 5-3 details the assumptions for the offsite storage alternative.

The storage facility was assumed to be owned and operated by the District. Cake would be stored in enclosed bunkers and odor control would be included. The offsite storage facility would be staffed three shifts per day when biosolids are being diverted to and from the facility. The operation of the storage facility would entail use of a front-end loader to move biosolids from the receiving area to the bunkers and loading biosolids from the bunkers to the hauling trucks. An allowance of 0.5 FTE was included for equipment maintenance. The total number of FTEs for the operation of the storage scenarios is summarized in Table 5-3.

Table 5-3. Modified status quo - offsite storage (Alternative 0A) planning criteria

Item	2-Months Storage, Contract Hauling	2-Months Storage, District Hauling	4-Months Storage	6-Months Storage, Pinole	6-Months Storage, Merced
2050 total cake production, wtpy	107,000	107,000	107,000	107,000	107,000
Biosolids to land application, wtpy	75,000	75,000	91,000	91,000	91,000
Biosolids to merchant facilities, wtpy[a]	32,000	32,000	16,000	16,000	16,000
Number of biosolids trucks at MWWTP in 2050	15	15	15	15	15
Biogas production and utilization in 2050					
Average biogas production rate, scfm	3,200	3,200	3,200	3,200	3,200
Biogas diverted to PGS, scfm	3,050	3,050	3,050	3,050	3,050
Biogas used with boiler, scfm	0	0	0	0	0
Biogas flared, scfm	150	150	150	150	150
Aggregate biosolids management costs in 2050, $/wet ton	$133	$129	$115	$121	$112
Storage building footprint[b], ft^2	61,000	61,000	111,000	171,000	171,000
Total land requirements, acres	2	2	3	4	4
Assumed location for facility	District-owned Pinole property	District-owned Pinole property	District-owned Pinole property	District-owned Pinole property	Merced county (site TBD)
Hauling to storage facility	Contractor	District	Contractor	Contractor	Contractor
FTEs for facility O&M and hauling[c]	2.5	4.0	3.5	5.0	5.0

a. Under the 2-months storage scenario, 30% of biosolids are diverted to merchant facilities to provide adequate outlets under average and wet years. Under the 4-month and 6-month scenarios, 15% of biosolids are diverted to merchant facilities to maintain a diversified biosolids management portfolio.

b. Footprint includes enclosed bunkers and a 600-square-foot (ft^2) office area.

c. FTE estimates include 0.5 FTE for maintenance of the facility plus additional FTEs for operation of the front-end loader to move biosolids in and out of storage bunkers during storage operation. District hauling includes 5 FTEs for 2-month duration, and 1 FTE for 4-month duration for truck management.

The considerations for the offsite storage facility included the following: hauling to the storage facility, facility siting, and storage duration.

Hauling to Storage Facility

Contract hauling versus District hauling from the MWWTP to the offsite storage facility was evaluated. It was assumed that biosolids would be hauled from the offsite storage to the land application site by a contractor.

District hauling to the storage facility would require the District to purchase trucks (5 trucks assumed) and hire staff for hauling biosolids. A total of 5 FTEs was assumed during diversions to the storage facility and one FTE was assumed for management of biosolids trucks. An NPV comparison (Table 5-4) was performed (using a standard assumption of 2 months of storage for comparison purposes) to determine whether there is an economic benefit to the District performing its own hauling to a storage site. The NPV analysis also included an allowance for diesel fuel and truck maintenance. Contract hauling was assumed to have a cost of $0.10 per mile in 2020 with an additional $5.60 per wet ton for driver wait time during loading and unloading. The costs were increased with the CPI each year and are based on discussions with contractors and recent experience at other facilities. The analysis confirmed that the NPV of contract hauling versus District hauling is similar (Table 5-4 and Figure 5-4). Contract hauling was carried forward at the direction of the District for alternatives development because it simplifies the management of trucks and minimizes new staff and new equipment.

Table 5-4. Economic Evaluation of offsite storage options (Alternative 0A)

Item	2-Months Storage, Contract Hauling	2-Months Storage, District Hauling	4-Months Storage	6-Months Storage, Pinole	6-Months Storage, Merced
Capital costs, $ millions[a]	$60	$60	$96	$127	$126
Annual operating costs (year 1), $ millions[b]	$7.4	$7.2	$6.8	$8.6	$8.6
R&R costs (year 1), $ millions	$0.3	$0.3	$0.4	$0.4	$0.4
Annual revenue (year 1), $ millions	$2.2	$2.2	$2.2	$2.2	$2.2
NPV, $ millions[c]	$265	$270	$285	$345	$333

a. Capital costs presented in 2021 dollars. Capital costs include offsite storage facility and sludge screening at the MWWTP.
b. Annual operating costs presented in 2021 dollars. Annual operating costs are presented for Year 1 of operation and include biosolids management costs, labor and fuel for hauling, labor for operations and maintenance (O&M) of storage facility, and energy.
c. NPV presented in 2021 dollars and includes the revenue from sale of excess power generation ($0.0568/kWh).

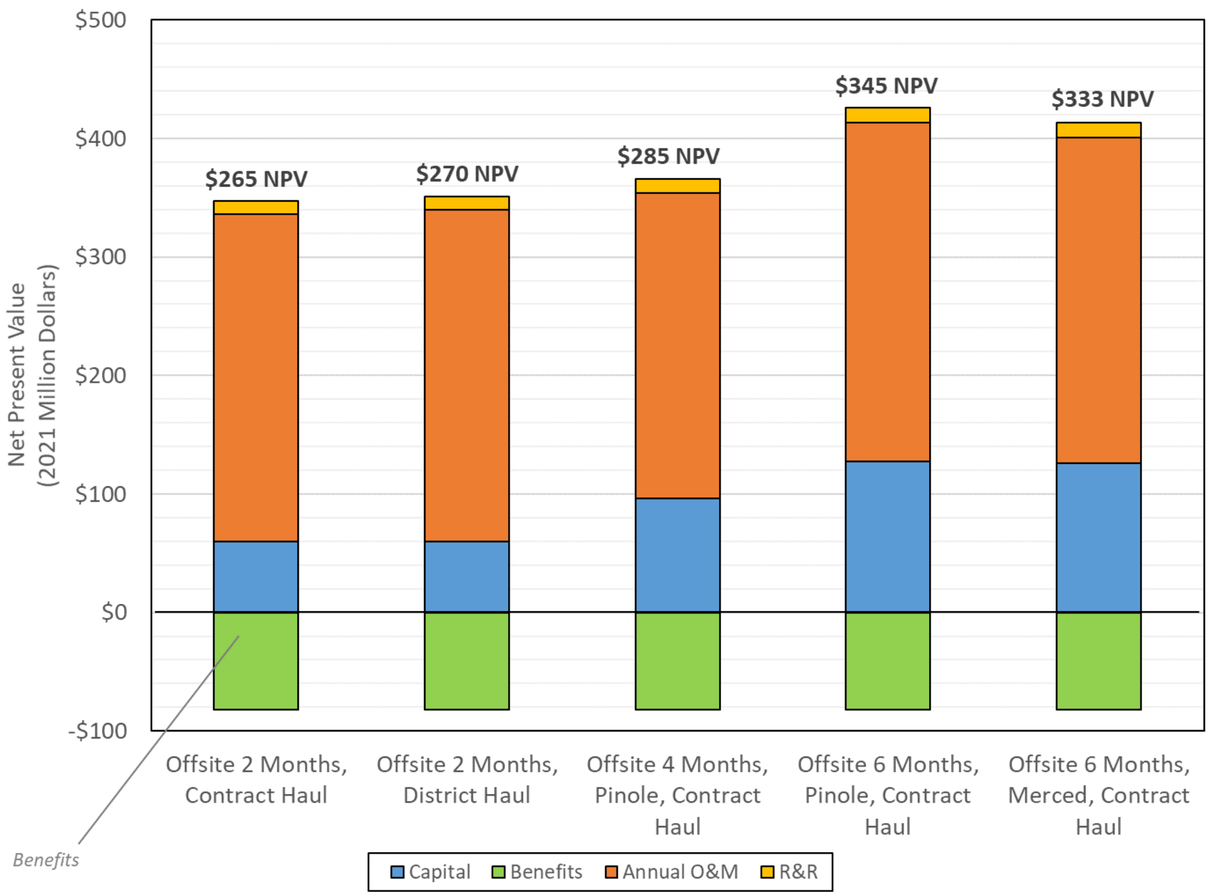

Figure 5-4. Modified status quo – offsite storage (Alternative 0A) Economic Evaluation

Facility Siting

Two locations for offsite storage were considered: (1) District-owned Pinole property and (2) an undetermined property in Merced County. Other District-owned property, such as the Point Isabel Wet Weather Facility and the North Richmond Water Reclamation Treatment Facility were considered; however, they were not carried forward because the two sites do not have adequate land available.

The Pinole property is surrounded by residential communities and may be difficult to permit but offers the benefit of being located both near the MWWTP as well as potential land application sites, which streamlines O&M. Locating a facility in Merced County offers the advantage of being close to the land application sites; however, the District would need to identify and purchase a site, and permit the site for its intended use. The permitting and mitigation requirements for a site in Merced County are unknown and additional analysis is needed to confirm the feasibility and cost of land and mitigation/permitting efforts. A storage facility in Merced would also be a remote operation, which would likely increase complexity and costs of overall operations.

The two siting options were compared at a high level, with the economics being developed around the assumption of a 6-month storage facility, which is the maximum length of storage required, and thus a conservative economic scenario. As shown in Table 5-4, the capital cost and NPV for the two potential sites were similar, with Merced having a slightly lower NPV. It is important to note, however, that this NPV is based on a hypothetical plot of land for which a typical per acre price of land in Merced County was applied. Because the NPVs for the two siting locations were similar, offsite storage was assumed to be located at the District-owned Pinole property because it offers some ease of O&M and better defined permitting requirements and costs.

It should be noted that the District could consider acquiring new property within the Bay Area; a property and siting analysis would be needed to confirm land availability, cost, and permitting requirements. If offsite storage is further considered, additional analysis is needed to confirm permitting requirements and feasibility of acquiring new property in Merced County or elsewhere in the Bay Area.

Storage Duration

The economic benefits associated with winter storage were analyzed under three scenarios: 2 months, 4 months, and 6 months of storage. As noted in Table 5-3, the 4- and 6-month storage scenarios assume that 15% of biosolids cake is diverted to merchant facilities. The 2-month storage facility includes a higher diversion rate (30%) to merchant facilities to provide adequate outlets if the wet weather season is longer than 2 months, as would be expected. Following the economic analysis, the 4-month storage scenario was determined to be ideal because it provides adequate flexibility during wet weather months while still reducing the capital costs of the facility. Because diversion to merchant facilities was assumed for the different storage options, sludge screening was included in the capital costs. As noted previously, District Staff have noted that the quality of the biosolids cake may require screening to improve marketability and acceptance at merchant facilities.

The Modified Status Quo – Offsite Storage (Alternative 0A) was carried forward into the alternatives evaluation process assuming the facility is located on District-owned Pinole property, utilizes contract hauling, and is constructed to provide 4-months of cake storage. Although the NPV for the 2-month storage facility is slightly lower than the 4-month storage option, it was determined that the 2-month storage option did not provide as much flexibility with respect to biosolids management, given that the wet weather season is often longer than two months. If offsite cake storage is carried forward and further developed, the storage duration should be further considered to balance flexibility with capital costs.

5.4 Alternative 1 – Merchant Facilities

Under the merchant facilities alternative, the District would continue to produce Class B biosolids. All biosolids would be diverted to offsite merchant facilities for post-digestion treatment and beneficial use (Figure 5-5). One of the merchant facility options could be owned by multiple agencies under the BABC.

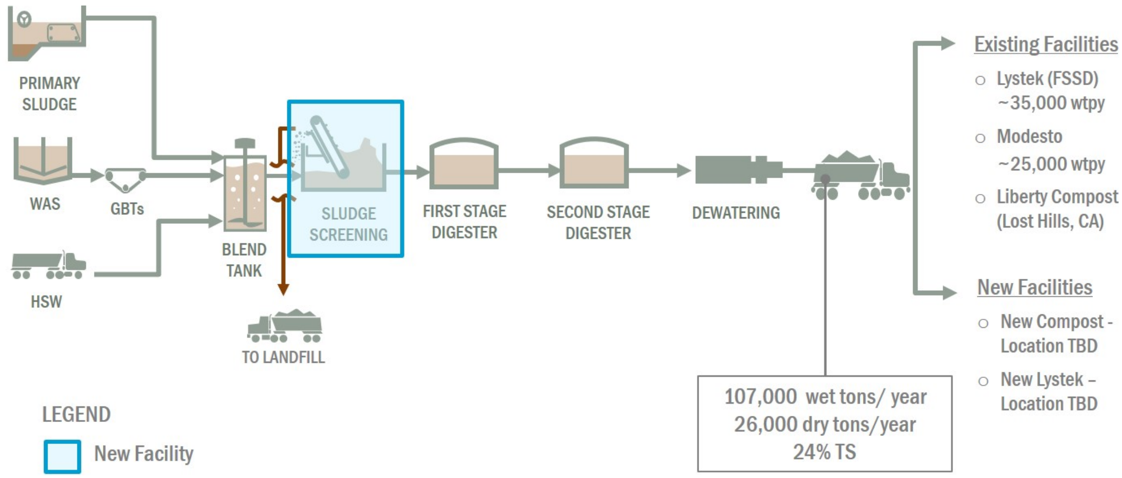

Figure 5-5. Merchant facilities (Alternative 1) schematic

As with Alternative 0A, this alternative assumes that sludge screening is constructed at the MWWTP to improve the quality of the biosolids. Table 5-5 provides the additional planning-level assumptions and criteria for this alternative. A key assumption with this alternative is that there is adequate capacity at existing merchant facilities and/or a new facility will be constructed in the region. Within the region, there currently is capacity at the Lystek facility at the Fairfield Suisun Sewer District (year-round capacity on the order of 35,000 wet tons/year). The remaining capacity at the Lystek facility is dynamic and may be secured in the near-term by other Bay Area agencies looking for alternative outlets. Two additional facilities also have capacity (as noted in Figure 5-5): (1) Liberty Hills Compost in Lost Hills, CA and (2) City of Modesto's compost facility. Liberty Hills Compost is located approximately 200 miles from the MWWTP, which would significantly increase hauling distances. The City of Modesto's facility has approximately 25,000 wet tons/year of capacity, but the facility requires the District to purchase compost in an amount equivalent to the biosolids sent to the facility. The District would then be responsible for marketing and distributing the compost.

Table 5-5. Merchant Facilities (Alternative 1) planning level criteria

Parameter	2050 Conditions
Screening facility	
Number of screens	4
Feed rate, mgd	1.0
Solids content, % TS	4.6
Facility details	Enclosed with odor control; strainpress system or similar
Biosolids end-use	
Land application, wtpy (wtpd)	107,000 (293)
Solids content	24
Number of biosolids trucks, trucks/day[a]	15
Aggregate biosolids management costs, $/wet tons	242
Total land requirements, acres	0.1
Additional FTEs	--
Biogas production and usage	
Average biogas production rate, scfm[b]	3,200
Biogas diverged to PGS, scfm	3,050
Biogas used with boiler, scfm	0
Biogas flared, scfm[b]	150
Natural gas purchased, therms/day	--

a. Assumes trucks haul 20 wet tons per load
b. Assumes 26 scf of biogas per pound volatile solids destroyed.

Currently, there are only tentative plans for a new merchant facility in the region. A new merchant facility would likely require a long-term (10 or more years) commitment from one or more agencies to secure funding for the facility's construction and operation. To date, the advancement of a new merchant facility in the Bay Area has been hindered by the lack of firm commitments from agencies.

The tipping fees at existing and new merchant facilities will be largely influenced by both the type of processing technology used, permitting requirements, and the demands for capacity. This alternative would reduce the control the District has over future biosolids management costs and will be subject to the prices established by the merchant facilities. This alternative provides the benefit of optimizing land use at the MWWTP and minimizing new capital improvements.

5.5 Alternative 2 – Pre-Digestion, THP

Under this alternative, THP would be constructed upstream of the existing anaerobic digesters and would produce a Class A THP cake, as shown on Figure 5-6. The market assessment identified land application as the primary end-use with a THP cake; while there may be potential to distribute THP cake to local soil blending operations, additional development of this market is needed for it to be considered a reliable outlet. Thus, this alternative would have the same beneficial use outlets as the Status Quo Alternative (Alternative 0) and would rely on land application and merchant facilities.

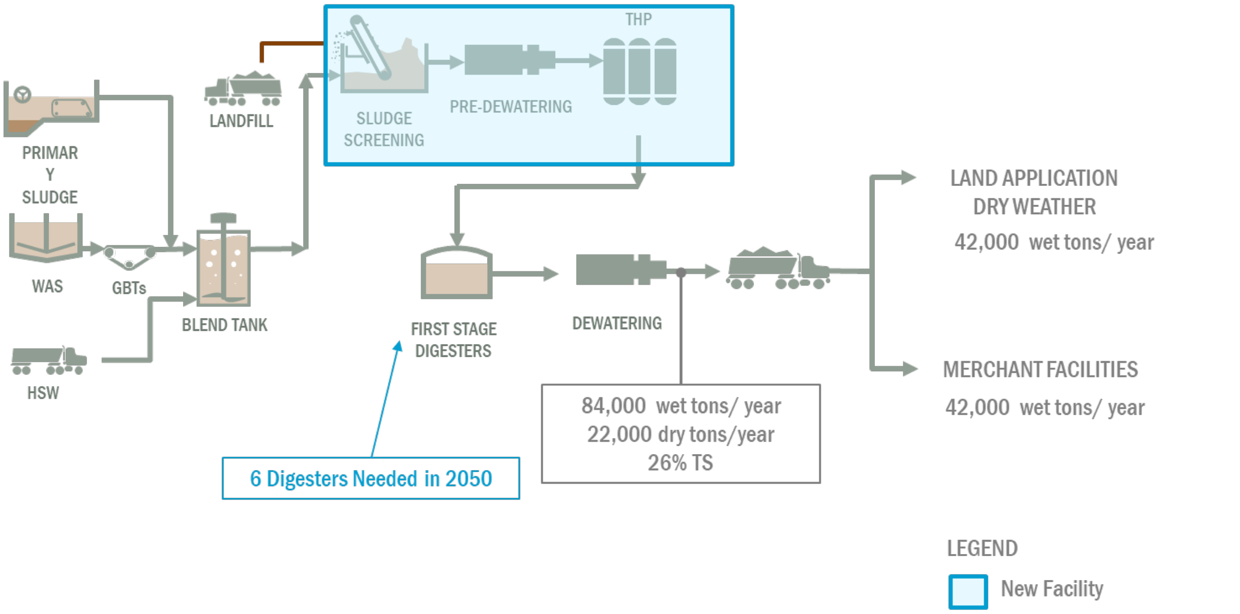

Figure 5-6. THP (Alternative 2) process schematic

THP would require approximately 3 acres of land. If storage were constructed at the MWWTP, an additional 3 acres of land would be required. Due to the large land requirement for cake storage, this alternative assumes that storage would not be constructed at the MWWTP. The THP cake would instead be beneficially used similar to the Status Quo (Alternative 0), where 50% of cake is land applied and the remaining 50% is distributed to merchant facilities and/or stored for land application. Unlike traditional Class B or Class A cake, THP cake can have reduced odors and is typically stable under storage conditions. For example, there are European installations where THP cake is stored in winter months with few to no offsite odor impacts. If this alternative is carried forward, additional effort should focus on development of new markets for the THP cake to help reduce end-use costs.

THP typically offers the benefits of increasing digester capacity, improving dewaterability of digested solids, and increasing the volatile solids reduction (VSR) and biogas production. At the MWWTP, the existing digester capacity was found to be adequate for the planning horizon. Thus, the benefits of THP would primarily be associated with the potential for improved dewaterability and increased biogas production. This alternative would eliminate the need to perform the post-tensioning improvements on the second-stage digesters that are in the current CIP as part of the Digester Phase 4 Project. This would reduce capital expenses by an estimated $13.1 million. This savings was considered in the NPV presented in Section 5.8.

Under this alternative, the VSR was assumed to increase to 65% (increase from current VSR of 61%). Additional biogas that is produced would be used to offset heating demands associated with the THP process. The THP system will require 5,700 therms per day of steam (lower heating value) to pretreat the solids; high-quality heat is required, which is typically not easily recovered from engines. Thus, in 2050, natural gas is still needed for the THP process (refer to Table 5-6).

Table 5-6. THP (Alternative 2) planning criteria

Parameter	2050 Value
Screening facility	
Number of screens	4
Feed rate, mgd	1.0
Solids content, % TS	4.6
Facility details	Enclosed with odor control; strainpress system or similar
Pre-dewatering system	
Dewatering units	Centrifuges
No. of units	6
Feed rate, mgd	1.0
Polymer consumption, lbs neat polymer/day	5,300
Feed solids content, % TS	4.4
Dewatered solids content, % TS	20
THP system	
No. of trains	3
Operating temperature, °F	300
Operating pressure, pounds per square inch	87
Feed rate, mgd	0.3
Heat requirements (steam demand), therms/day	5,700
Energy demand, MW	0.4
Post-digestion dewatering	
Feed rate, gallons per minute	300
Feed solids content, % TS	5
Dewatered solids content, % TS	26
Polymer Consumption, lbs neat polymer, day	3,500
Biosolids end-use	
Land application, wtpy (wtpd)	84,000 (230)
Solids content, % TS	26
Number of biosolids trucks, trucks/day[a]	12
Aggregate biosolids management costs, $/wet ton	161
Total land requirements (without cake storage), acres	2.6
Additional FTEs	6
Biogas production and utilization in 2050[b, c]	
Average biogas production rate, scfm[a]	3,200
Biogas diverged to PGS, scfm	2,700
Biogas utilized with THP boiler, scfm	500
Biogas flared, scfm	0
Natural gas purchased in 2050, therms/day	4,200[c]

a. Assumes trucks haul 20 wet tons per load.

b. Assumes 26 scf of biogas per pound volatile solids destroyed.

c. Boiler demand is 5,700 therms/day, of which 1,500 therms/day is supplied with biogas, all based on lower heating value.

The THP process includes a pre-dewatering step (upstream of digestion) in addition to the final dewatering step. THP typically improves dewaterability of the digested solids (final dewatering step) such that polymer use can be reduced while producing a dryer cake. However, because polymer addition is required in two dewatering steps, it was assumed that the overall polymer use at the MWWTP would remain the same as current practice. The final product was assumed to have a 26% solids content, which is higher than the current average of 23% to 24% solids.

Ammonia and recalcitrant dissolved organic nitrogen (rDON) levels are expected to increase in the dewatering centrate from THP. Based on observations at other THP facilities, a 7% to 10% increase in ammonia load and a 1 milligram/liter (mg/L) increase in rDON can be expected. As noted in E20 Regulatory Requirements, nutrient discharge regulations may include a total inorganic nitrogen (TIN) load cap. Thus, the additional ammonia load in the centrate from THP would result in higher TIN loads discharged to the Bay. Sidestream treatment can reduce this impact; however, the design criteria would need to be modified to accommodate this additional load. If this alternative is carried forward, the additional loads in the dewatering return flows will be considered with the development of nutrient reduction alternatives.

5.6 Alternative 3 – Post-Digestion, Thermal Drying

Alternative 3 considers thermal drying for all biosolids processed at the MWWTP. A key advantage of thermal drying is the achieved volume reduction, which reduces hauling, storage, and end-use-management costs. The market assessment identified several end-use markets for a thermally dried pellet (e.g., fertilizer blending, soil blending, and horticulture); thus, new end-uses are viable with production of a high-quality pellet.

Figure 5-7 presents a schematic of this alternative. The alternative assumes that approximately 9,000 wet tons/year of pellets are distributed to new markets and the remainder of the pellets are land applied. The quantity of pellets diverted to new markets could grow beyond the assumed value; however, to be conservative, a lower volume of pellets diverted to fertilizer/soil blending markets was assumed initially. Based on the market assessment findings, the dried product value assumed for this alternative is $8/ton when sold to fertilizer and soil blending markets; land application unit costs were assumed to increase over time as described in Section 3.3.

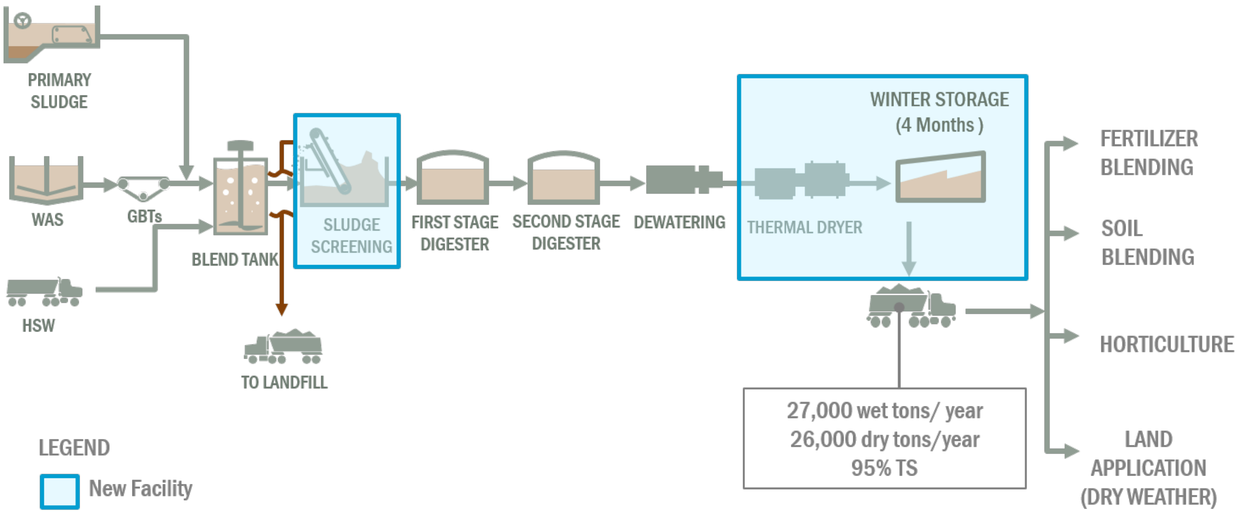

Figure 5-7. Thermal drying (Alternative 3) schematic

Sludge screening upstream of the first-stage digesters was included to improve pellet quality. A direct drum dryer was used as the representative technology because it is more common at larger plants and produces a high-quality pellet, suitable for the end-uses noted above. Because the direct dryers have a large energy and natural gas demand at startup most systems operate for 24 hours per day, 5 to 7 days per week. The dryer was sized for 2050 conditions assuming a 7-day-per-week operation. Prior to 2050, the thermal dryer would only need to be operated 5 to 6 days per week. Dryer scheduled maintenance would occur when not in use. Ideally maintenance would be scheduled during the dry season so that the cake can be land applied instead of being sent to a merchant.

The thermal dryer would be located in an enclosed building with odor control. The building could be designed to also include the dewatering centrifuges; for the purposes of this analysis dewatering was not included with the thermal dryer building. Pellet storage was included for storage during wet weather months (4 months is assumed). Due to the nature of the pellets, the storage facility would be a series of silos. Safety measures would be included to provide fire prevention and worker safety of stored pellets.

Table 5-7 summarizes key assumptions and planning-level criteria for this option. The alternative was developed assuming one thermal dryer is installed in the building; the building would be constructed with space for a second dryer to be installed in the future to treat peak loads and/or to provide redundancy. Because there would not be a redundant dryer, the District would rely on land application of Class B cake and/or diversion to merchant facilities during planned or unplanned maintenance of the thermal dryer. In addition, the alternative assumes that biogas is prioritized to the District's cogeneration system. After 2040, there would be biogas available to offset the natural gas demands of the thermal dryer, but the majority of the thermal dryer heat demands would be met with natural gas.

Table 5-7. Thermal Dryer (Alternative 3) planning criteria

Parameter	Alt 3 2050 Value
Screening facility	
Number of screens	4
Feed rate, mgd	1.0
Solids content, % TS	4.6
Facility details	Enclosed with odor control; strainpress system or similar
Dryer facility	
Building footprint, ft^2	25,300 ft^2
Dryer type	Direct, drum dryer
Number of dryers	1
Feed rate, wtpd	290
Feed solids content, % TS	24
Product/pellet solids content, % TS	95
Heat requirements, therms/day (lower heating value [LHV])	6,900
Electrical demand, MW	0.6
Dryer Operation, days per week	7
Pellet Storage	
Number of silos	8
Diameter of each silo, feet (ft)	28
Land for storage, acres	0.25
Biosolids end-use	
Land application, wtpy	18,100
Alternative markets (fertilizer/soil blending, horticulture, and specialty), wtpy	8,900
Number of biosolids trucks, trucks/day[a]	4
Aggregate biosolids management costs, $/wt	54
Total land requirements, acres	0.9
Additional FTEs[b]	5
Biogas production and usage[c, d]	
Average biogas production rate, scfm	3,200
Biogas diverted to PGS, scfm	3,050
Biogas to thermal dryer, scfm	150
Biogas flared, scfm	0
Natural gas purchased, therms/day (LHV)	5,700[d]

a. Assumes trucks haul 20 wet tons per load.
b. Represents the number of new FTEs in addition to existing Staff to operate and maintain new unit processes.
c. Assumes 26 scf of biogas per pound of volatile solids destroyed.
d. Assumes biogas is prioritized to the cogeneration system. As the District develops the biogas utilization roadmap, biogas could be reprioritized to the thermal dryer operation to reduce natural gas use.

It should be noted that biogas prioritization could be modified with this alternative. If the biogas prioritization was modified to meet the demands of the thermal dryer, the District could eliminate natural gas use in 2050. The dryer could operate on biogas produced at the MWWTP and still generate approximately 9 MW of power at the District's cogeneration facility. As the District develops its biogas utilization roadmap, this should be considered as an option to reduce the operating cost of the thermal dryer, as well as greenhouse gas emissions associated with the thermal dryer operation.

The thermal dryer will produce an ammonia-rich condensate stream that would be returned to the secondary influent. The condensate stream will increase ammonia loading to the liquid stream by approximately 8%; the increase is based on liquid being removed from the cake. If this alternative is carried forward, the impact of the increased load on nutrient discharges will be considered.

5.6.1 Alternative 4 – Post-Digestion, Lystek

The Lystek process is a chemical, thermal hydrolysis post-digestion process that involves increasing the pH and temperature of the biosolids to produce a Class A product (see Figure 5-8). The Lystek product is 15% to 16% solids, and the processing alters the viscosity of the product such that it behaves like a liquid (i.e., pumpable). The main market for the Lystek product is land application. The Lystek product is typically land applied subsurface, and because Lystek has registered the product as a fertilizer, some counties have relieved Lystek from ordinance-related land application restrictions. Storage of the product during wet weather months would be needed during periods of heavy rains when land application is not possible.

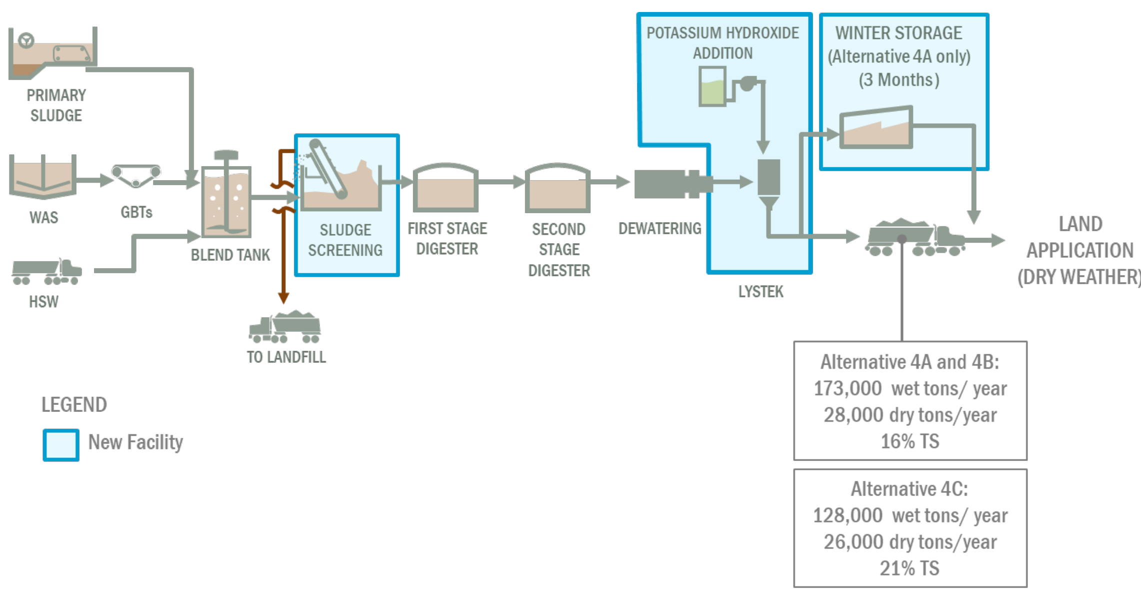

Figure 5-8. Lystek (Alternative 4) process schematic

Three scenarios were considered for this alternative: (1) year-round Lystek processing of all biosolids with 3 months of onsite storage (Alternative 4A), (2) year-round Lystek processing of all biosolids without onsite storage (Alternative 4B), and (3) seasonal operation of Lystek without onsite storage (i.e., 4 months of the year [Alternative 4C]). Alternative 4C assumes that during dry weather months, the Lystek facility is not operated and a Class B cake (status quo) is produced and hauled offsite for land application. The difference between Alternatives 4B and 4C is the operating costs of the Lystek facility. Because the Lystek product has a larger volume than status quo due to the reduced solids content, Alternative 4C minimizes impacts and costs associated with truck traffic and product hauling. Note that some storage would be required during periods of heavy or consistent rain, when the ground is saturated. Under Alternatives 4B and 4C, it was assumed that Lystek would manage the District's product in offsite storage near a land application site. Offsite storage costs would need to be developed in conjunction with Lystek if these alternatives were to be pursued and are not included at this time. These costs would increase the overall NPV of Alternatives 4B and 4C.

Table 5-8 provides a summary of key planning-level criteria. The Lystek facility would be located in an enclosed building. Due to the liquid nature of the product, storage in partially buried concrete tanks was assumed (Alternative 4A only). To avoid the need for a lime slaking system, potassium hydroxide was assumed to raise the pH (instead of lime). Biogas produced at the MWWTP was prioritized to the cogeneration system with excess biogas sent to the flare.

Table 5-8. Alternative 4A and 4B planning level criteria

Parameter	Year-Round Operation with Storage (Alt 4A) 2050 Value	Year-Round Operation without Storage (Alt 4B) 2050 Value	Seasonal Operation without Storage (Alt 4C) 2050 Value
Screening facility			
Number of screens	4	4	4
Feed rate per unit, mgd	0.5	0.5	0.5
Solids content, % TS	4.6	4.6	4.6
Lystek facility			
Operating months per year	12	12	4
Building footprint, ft^2	4,200	4,200	4,200
Number of units	4	4	4
Total Feed rate, mgd	0.1	0.1	0.1
Feed solids content, % TS	15	15	15
Product solids content, % TS[a]	16	16	16
Heat requirements, therms/year	281,050	281,050	92,400
Electricity demand, MW	0.1	0.1	0.02

Parameter	Year-Round Operation with Storage (Alt 4A) 2050 Value	Year-Round Operation without Storage (Alt 4B) 2050 Value	Seasonal Operation without Storage (Alt 4C) 2050 Value
Storage facility			
Type of storage	Concrete Tank	--[b]	--[b]
No. of tanks	8		--
Diameter of tanks, ft	100	--	--
Volume stored, million gallons	16.2	--	--
Land required, acres	2.3	--	--
Biosolids end-use			
Land application of lystek material,	173,000	173,000	57,000
wtpy	--	--	71,000
Land application of biosolids cake,	16	16	21
wtpy	24	24	18
Aggregate solids content, % TS	16	16	20.5
Number of biosolids trucks, trucks/day[a]	237	237	176
Aggregate biosolids management costs $/wet ton	80	80[b]	80[b]
Total land requirements, acres	2.7	0.4	0.4
Additional FTEs[c]	5	5	2.5
Biogas production and usage in 2050[d]			
Average biogas production rate[a], scfm	3,200	3,200	3,200
Biogas diverted to PGS, scfm	3,050	3,050	3,050
Biogas used with Lystek scfm	0	0	0
Biogas flared, scfm	150	150	150
Natural gas purchased, therms/day	0	0	0
Chemicals Use			
Potassium hydroxide, gpd	150	150	50
Chemical trucks, trucks/year[e]	6	6	2

a. Assumes volume of 10,000 gallons per truck.

b. Does not include cost to build and manage offsite storage of Lystek product during wet weather months. Such costs would be developed with Lystek and would likely increase the overall NPV of these alternatives.

c. Represents the number of new FTEs in addition to existing Staff to operate and maintain new unit processes.

d. Assumes 26 scf of biogas per pound of volatile solids destroyed.

e. Increase in solids content is due to chemical addition to raise pH, which adds inert solids to the process.

The Lystek product was assumed to be land applied because at this time no other markets for the product have been identified. It was assumed that the facility would be operated by District Staff, but that the beneficial use of the final product would be managed by Lystek. As noted above, for Alternatives 4B and 4C, this includes offsite storage of the product. As with offsite storage, the management fee was not included in the current economic evaluation as it is assumed that it would be built into the offsite storage fee.

As noted above, the digested solids fed to the Lystek facility have a lower solids content (15%). This means more liquid is retained with the biosolids and ultimately hauled offsite. Thus, the volume of dewatering centrate routed back to the secondary system is lower than with status quo and/or with thermal drying. In addition, the ammonia load returned to the secondary system in the dewatering centrate is also reduced. Based on a mass balance, the reduction in dewatering centrate flow equates approximately to a 5% load reduction of ammonia that is routed back to the secondary treatment system. If this alternative is carried forward, there would be a reduction in TIN discharges that should be accounted for in the timing of nutrient reduction.

Table 5-9 presents the NPV of the three Lystek options that were considered. Alternative 4C has the lowest NPV because it minimizes both capital and operating costs. For this reason, Alternative 4C was carried forward into the alternatives evaluation (Section 5.8). If Lystek is carried forward, the District should monitor the development of new end-use markets for the Lystek product, as well as confirm the optimal wet weather management strategy and the need for and cost of onsite or offsite storage.

Table 5-9. Economic evaluation of Lystek options (Alternative 4)

Item	Year-round Lystek with 3-months onsite storage (Alt 4A)	Year-round Lystek without onsite storage (Alt 4B)	Seasonal operation Lystek without onsite storage (Alt 4C)
Capital costs, $ millions[a]	$189	$94	$94
Annual operating costs (year 1), $ millions[b]	$10.3	$10.3[c]	$6.1[c]
R&R costs (year 1)	$0.5	$0.5	$0.5
Revenue generation (year 1)	$2.2	$2.2	$2.2
NPV, $ millions[d]	$513	$418	$255

a. Capital costs presented in 2021 dollars. Capital costs include sludge screening at the MWWTP.
b. Annual operating costs presented in 2021 dollars. Annual operating costs are presented for Year 1 of operation and include biosolids management costs, labor, chemicals, and annual licensing fees.
c. Costs do not include wet weather storage.
d. NPV presented in 2021 dollars and includes the revenue from sale of excess power generation at $0.0568/kWh.

5.7 Alternative 5 – Post Digestion, Pyrolysis

Alternative 5 consists of post-digestion pyrolysis that would produce a biochar product that could be used in new end-use markets (see Figure 5-9). This alternative was developed around the BioForce Tech system, as this is the only commercially proven pyrolysis system, although others are in various stages of development. Application at the MWWTP would be the largest operating pyrolysis system for BioForce Tech.

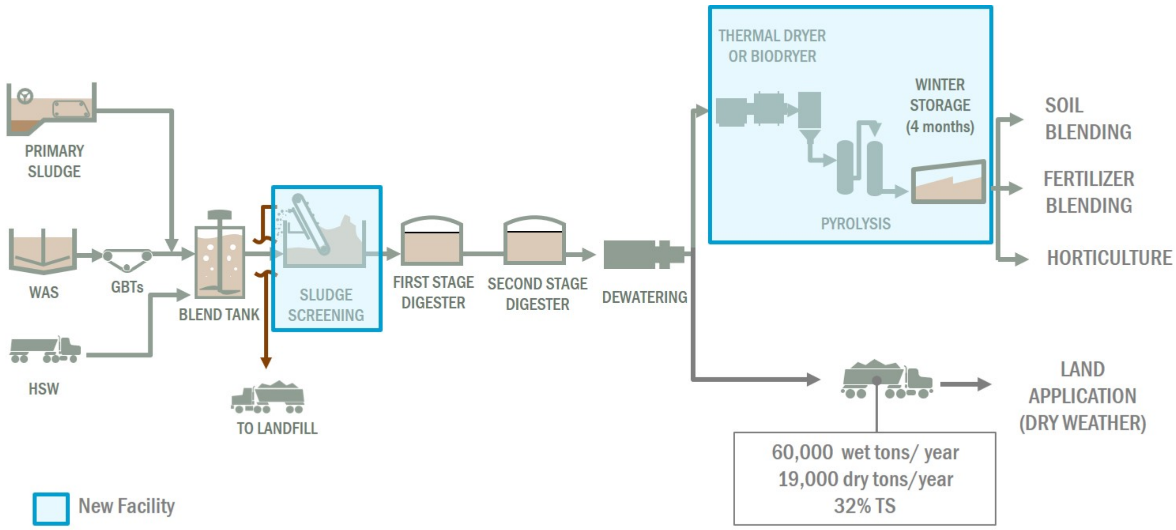

Figure 5-9. Pyrolysis (Alternative 5) process schematic (based on BioForce Tech technology)

The pyrolysis system was sized to treat 100% of biosolids. As the market for biochar is still emerging and the local demand for the product is unknown, it was assumed that only 50% of the biochar produced was sold as biochar. The remaining biochar was land applied at the same tip fee as for Class B cake. Because the exact timing of demands for biochar are not well established, 4 months of biochar storage (or 4,000 cubic yards) was included in the facility footprint and costs to provide market flexibility. A bagging system is included in the capital cost to allow for ease of product storage and distribution. Bags of biochar can safely be stored on pallets in the storage facility. A net value of $8 per ton was assumed for the biochar product. The biochar value and end-uses should be monitored as the biochar market becomes more established.

The pyrolysis system relies on natural gas during startup only; once the system is started, syngas that is produced during pyrolysis is used to heat the reactors and to dry the feed sludge. The drying of feed sludge can be achieved using a biodryer or a direct drum thermal dryer (as described as Alternative 3). Biodryers would be provided by the pyrolysis manufacturer and would use syngas produced in the pyrolysis step. For this alternative, biodryers were assumed so as to minimize natural gas use. A direct drum thermal dryer (as described in Alternative 3) was not assumed but could be considered during subsequent development of this alternative. If direct drum thermal dryers are considered instead of biodryers, additional natural gas or biogas would be needed because the syngas would not provide sufficient heat for use in the direct drum thermal dryer. Thus, the system requires a minimal amount of natural gas if a biodryer is used (as opposed to a direct drum thermal dryer). Table 5-10 provides assumptions and key criteria for the development of this alternative.

Table 5-10. Pyrolysis (Alternative 5) planning criteria

Parameter	2050 Value
Screening facility	
Number of screens	4
Feed rate, mgd	1
Solids content, % TS	4.6
Biodryer and pyrolysis facility	
Building size, ft^2	72,000
Dryer type	Biodryer (BioForce Tech)
Number of biodryers per train	8
Number of pyrolysis reactors per train	1
Number of trains	4
Feed rate per train, wtpd per train	73
Feed solids content, % TS	24
Biochar solids content, % TS	95
Biochar storage type	Bagged, stored in the facility
Heat requirements, therms/day	4,000
Electricity demand, MW	0.2
Biosolids end-use	
Land application of class B cake, wtpy	53,000
Biochar to fertilizer blending, soil blending, horticulture markets, wtpy	7,000
Number of biosolids trucks, trucks per day[a]	8
Aggregate biosolids management costs, $/wet ton	80
Total land requirements, acres	1.7
Additional FTEs[b]	5
Biogas production and usage	
Average biogas production rate, scfm	3,200
Biogas diverted to PGS, scfm	3,050
Biogas used with boiler, scfm	0
Biogas flared, scfm	150
Natural gas purchased in 2050, therms/day[c]	34

a. Assumes trucks haul 20 wet tons per load.
b. Represents the number of new FTEs in addition to existing Staff to operate and maintain new unit processes.
c. Natural gas assumed to be needed for startup only. Four startups are assumed per year.

Pyrolysis provides several key advantages that include new potential end-use markets for biochar, potential PFAS destruction due to higher operating temperatures, and volume reduction. While there is limited operational experience at this time, the District should monitor new installations and operating experience. A pyrolysis system could be phased over time as the technology matures and achieves more operational experience. For example, a pyrolysis system could be installed later in the planning phase, after thermal drying.

5.8 Alternatives Analysis

5.8.1 Economic Evaluation

An NPV analysis was performed for the biosolids alternatives. The NPV was developed over a 30-year period assuming a 2% discount rate and 3% inflation rate. A summary of the NPV is presented in Table 5-11. Appendix F provides additional details on the capital, O&M, and benefit assumptions, as well as the NPV results.

Table 5-11. Summary of economic evaluation of Alternatives 1 through 5

	Alternative 0 Status Quo	Alternative 0A Modified Status Quo	Alternative 1 Merchant Facilities	Alternative 2 THP	Alternative 3 Thermal Dryer	Alternative 4 Lystek - Seasonal Operation	Alternative 5 Pyrolysis
Capital Costs ($ Millions)							
Treatment/Storage Facility	$--	$80.7[a]	$--	$600.2	$199.0[b]	$78.0[c]	$354.1[b]
Solids screening	$--	$15.6	$15.6	$--[d]	$15.6	$15.6	$15.6
Total Capital Cost, $ millions (2021)	$--	$96.3	$15.6	$600.2	$214.6	$93.6	$369.7
Annual Operating Costs ($ Millions)							
Licensing fees PV, $ millions (2021)	$0.0	$0.0	$0.0	$0.0	$0.0	$1.7	$0.0
Chemical PV, $ millions (2021)	$54.5	$55.4	$54.5	$120.0	$57.0	$55.3	$54.6
Labor PV, $ millions (2021)	$5.3	$37.1	$0.0	$63.6	$53.0	$26.5	$53.0
Natural gas PV, $ millions (2021)	$0.0	$0.0	$0.0	$64.3	$83.5	$0.0	$0.4
Biosolids management PV, $ millions (2021)	$231.1	$166.2	$350.7	$177.6	$19.9	$141.8	$7.2
R&R PV, $ millions (2021)	$0.0	$1.3[e]	$0.0	$87.8	$16.8	$6.8	$18.6
Screening PV, $ millions (2021)	$0.0	$10.5	$10.5	$0.0	$10.5	$10.5	$10.5
Total Operating Costs PV, $ millions (2021)	$290.9	$270.5	$415.7	$513.4	$240.8	$242.8	$144.3
Annual Revenue ($ Millions)							
Excess power generation (sale) PV, $ millions (2021)	($82.0)	($82.0)	($82.0)	($91.7)	($70.6)	($81.3)	($95.3)
Biosolids product sale PV, $ millions (2021)	$0	$0	$0	$0	($3.2)	$0	($1.7)
Annual Revenue PV, $ millions (2021)	($82.0)	($82.0)	($82.0)	($91.7)	($73.8)	($81.3)	($97.0)
Annual Revenue Present Value, $ Millions (2021)							
Net Present Value ($ millions)	$209	$285	$349	$1,022	$382	$255	$417

a. Offsite enclosed storage with odor control assumed. Four-month storage capacity provided. Location is assumed to be on District-owned property in Pinole. Cost for land is not included in the capital costs.
b. Alternative 3 includes 4 months of silo storage of pellets. Alternative 5 includes 4 months of biochar storage (bagged storage) based on manufacturer recommendation.
c. Does not include cost to build and manage offsite storage of Lystek product during wet weather months. Such costs would be developed with Lystek and would likely increase the overall NPV of these alternatives.
d. Sludge screening is included with the THP facility and is included in the THP facility costs.
e. R&R costs associated with equipment at the offsite storage location.

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The capital costs for the alternatives include all the new facilities that each alternative requires. The NPV does not include dewatering improvements that are needed to address aging infrastructure and solids capacity limitations. The dewatering improvements would be required for all biosolids alternatives and, therefore, were not considered as a differentiator among the alternatives. Similarly, seismic upgrades (post-tensioning improvements) to the second-stage digesters are in the District's current CIP and would apply to all biosolids alternatives with the exception of THP (Alternative 2). Because THP increases digester capacity, the seismic upgrades could be avoided with this option; this avoided capital cost ($13.1 million) was included as an avoided cost in the THP NPV.

Annual operating costs and benefits were also estimated for each alternative using BC's Solids Water Energy Evaluation Tool (SWEET). Operating costs include chemical use, additional labor required for new facilities, energy (electrical and natural gas), and R&R at 2% of major equipment. For all the alternatives, biogas was prioritized to the District's cogeneration system. Revenue generated from the sale of excess power was included as a benefit for each alternative. Revenue from the sale of biosolids products was also included as a benefit.

As shown in Table 5-11 and Figure 5-10, THP has the highest capital cost and NPV. Diversion to merchant facilities (Alternative 2) and Lystek with and without onsite storage (Alternatives 4A and 4B) also had higher NPVs. The status quo (Alternative 0), Modified Status Quo (Alternative 0A), thermal drying (Alternative 3), partial-year operation of Lystek (Alternative 4C), and pyrolysis had lower NPVs that were similar orders of magnitude.

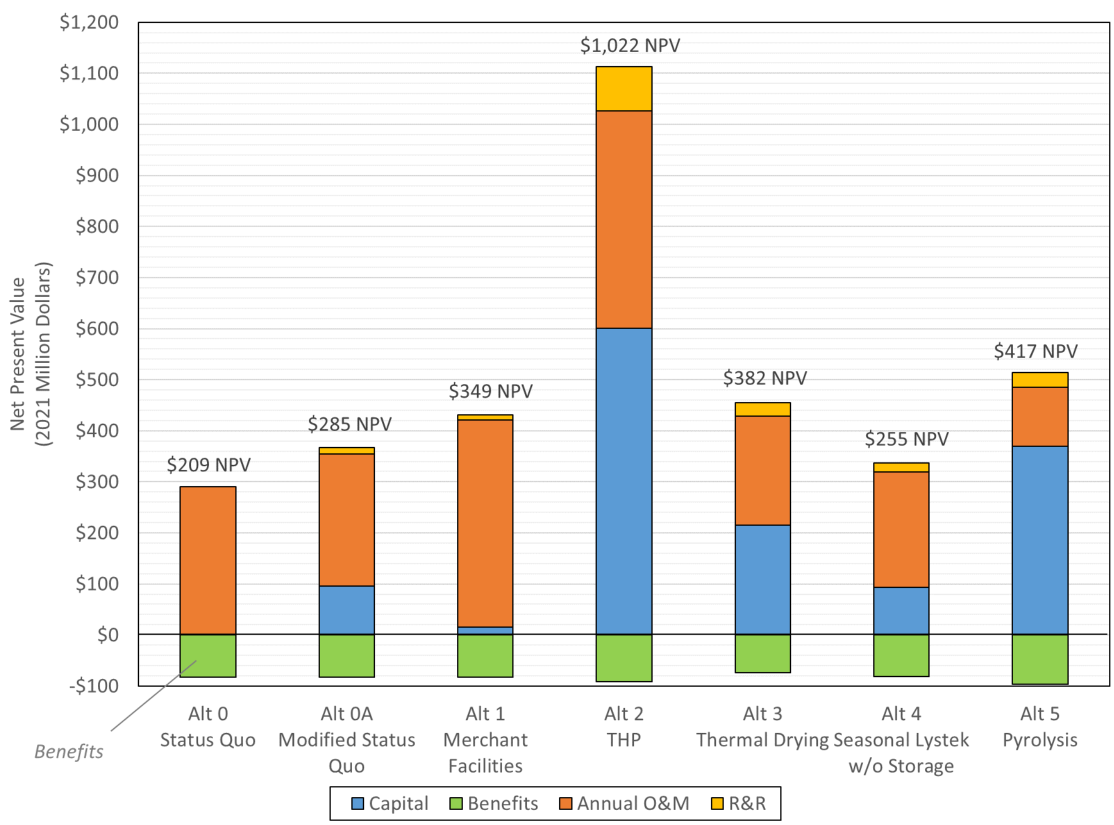

Figure 5-10. Summary of the net present values for each alternative

As noted in the above sections, if the District were to reprioritize biogas utilization such that more biogas was diverted to operating the biosolids facilities, the annual operating costs of THP and thermal drying would be reduced. The resulting NPV for THP and thermal drying would be $994 million and $418 million, respectively. THP would still have a significantly higher NPV than the other alternatives.

5.8.2 Non-Economic Evaluation

Alternatives 1 through 5 were evaluated using the non-economic criteria described in detail in the C50 Evaluation Criteria report (Carollo, 2021); the table of evaluation criteria is also provided as Appendix G. An extensive process was conducted to develop the evaluation criteria that were then ranked using a pairwise comparison methodology. The criteria include a combination of qualitative and quantitative criteria.

The top-weighted criteria from the pairwise comparison are:

- Facility Safety (Social)
- Flexibility to Meet Current and Future Regulations (Environmental)
- Technology Maturity and Reliability (Technical)

One key criterion that was quantified prior to scoring is the criterion “Minimize Greenhouse Gas Emissions.” The biosolids alternatives quantified the greenhouse gas (GHG) emissions, including process emissions (energy demands), fertilizer offset value, and carbon sequestration. All carbon sequestration assumed the same land application value. The GHG emissions were modeled mostly using Biosolids Emissions Assessment Model (BEAM) equations and reference values. BEAM is a peer-reviewed, Canadian model that was developed for the biosolids community. The GHG footprint included emissions from electricity and natural gas purchased, fugitive biogas, chemical production for chemicals used (polymer and caustic sodium hydroxide), landfill emissions, and hauling biosolids distance. The emissions did not include hauling distances of chemicals used or biogenic emissions from using biogas onsite. In addition, offsets considered included avoided purchased power, carbon sequestration, and offsetting synthetic fertilizers by land applying biosolids. The same factor and soil conditions were considered for carbon sequestration. The assumptions and calculations are detailed in Appendix H. Based on the GHG emissions, each alternative was assigned a score.

Figure 5-11 provides a summary of the results of the non-economic evaluation criteria. Appendix I provides the detailed scoring for each alternative and criterion.

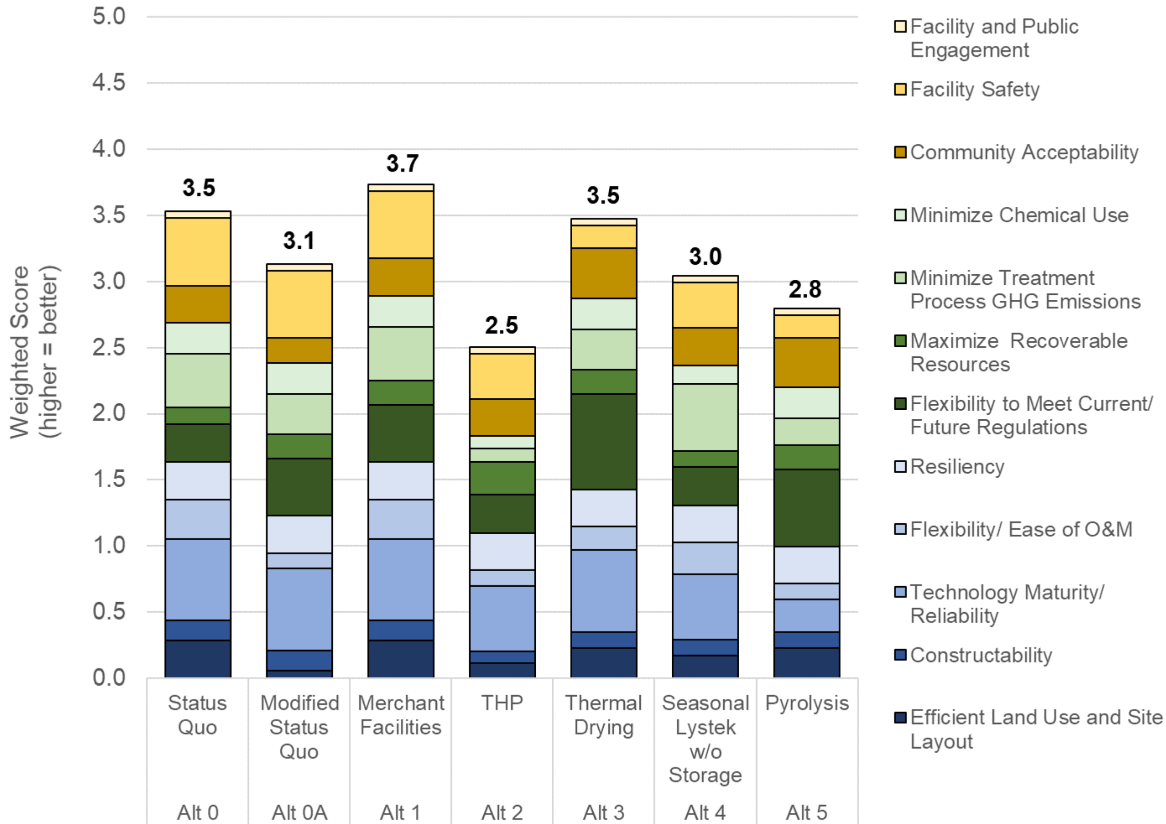

Figure 5-11. Summary of non-economic scores for each alternative

Alternatives 3 and 4 represent alternatives 3B and 4C.

5.8.3 Conclusion

The following are conclusions from the evaluation of alternatives:

- The status quo option (Alternative 0) has a 3.5 non-economic score, and the NPV of the alternative is comparable to several other alternatives. The economics of this option are dependent on future biosolids management costs. It is recommended that the status quo alternative be carried forward into the development of the biosolids roadmap as a near-term option. As a long-term strategy, this alternative is dependent on the District having adequate merchant facility (or similar) options during the wet weather months, similar to what is reflected in Alternatives 0A and 1.
- Offsite storage (modified status quo, Alternative 0A) has a 3.1 non-economic score. The NPV of this option is comparable to several other alternatives. Offsite storage would provide the District with a wet weather management strategy and would maximize biosolids land application. The main consideration with this alternative is finding a site that can be permitted for the storage facility. If a site can be secured and permitted, this alternative provides the District with near-term flexibility in biosolids management. For this reason, it is recommended that this alternative be carried forward into the development of the biosolids roadmap.

- THP (Alternative 2) has the lowest non-economic score and highest NPV. THP offers the advantages of higher-quality cake, increased digester capacity, and improved dewaterability; however, these benefits at the MWWTP are not great enough compared to the cost of the pre-digestion facility. For this reason, the THP alternative was eliminated from further consideration.
- Merchant facilities (Alternative 1) had the highest non-economic score but one of the higher NPVs. While diversion to merchant facilities would likely remain in the District's biosolids management portfolio, 100% diversion to merchant facilities is not recommended as a long-term management option to carry forward. The success of this alternative is dependent on other entities building merchant facilities with adequate capacity for the future. This alternative would likely require the District to enter into long-term, year-round agreements to create and secure merchant facility capacity. Additionally, the alternative limits the District's ability to control management costs, capacity, and management practices. This alternative does represent a worst-case scenario with respect to biosolids management costs and, therefore, could be considered as an upper boundary condition to compare alternatives against in the development of the biosolids management roadmap.
- Lystek (Alternative 4) and pyrolysis (Alternative 5) have similar non-economic scores. The Lystek alternative has a slightly lower NPV due to the lower capital and operating costs. It should be noted that as an emerging technology, there is greater uncertainty associated with the life-cycle costs of pyrolysis. The Lystek alternative does not include costs for storage during wet weather months (offsite or onsite). If storage is required, as is believed to be the case, the NPV of the Lystek alternative would increase. Currently, Lystek does not have established markets for end-uses other than land application; thus, the alternative does not offer new end-use markets; however, Lystek has worked with local counties to extend the land application season for its fertilizer product. The Lystek product has a lower solids content, which increases product volume (compared to status quo) and truck trips. It is recommended that the District continue to monitor Lystek as a post-digestion option to confirm project and operating costs as well as the development of new end-use markets.
- As noted above, pyrolysis (Alternative 5) has a similar non-economic score to Lystek but a slightly higher NPV than Lystek. Pyrolysis offers several advantages that include volume reduction and potential new end-use markets. The end-use market for the pyrolysis product (biochar) is being developed, and the demand for the product is unknown at this time. The technology is considered to be emerging and does not have operational history at larger municipal wastewater treatment facilities; thus, life-cycle costs have a greater degree of uncertainty than those associated with the other technologies. Due to the benefits that the alternative can provide, it is recommended that the District continue to monitor pyrolysis as a post-digestion option. The District should continue to monitor the installation, operational experience, and development of end-use markets, as well as the project and operating costs.
- Alternative 3 (Drying) has one of the highest non-economic scores and an NPV similar to pyrolysis and Lystek. Thermal drying is an established technology with established end-use markets, and well-known O&M costs. The technology also offers the benefit of volume reduction. It is recommended that thermal drying be carried forward into the biosolids management roadmap as the placeholder, post-digestion technology.

CHAPTER 6 - CONCLUSIONS AND NEXT STEPS

Based on the conclusions from the alternatives evaluation, it is recommended that the following alternatives be carried forward for further refinement and/or integration into the biosolids management roadmap:

- The status quo (Alternative 0) should be carried forward into the development of the biosolids roadmap as a near-term option until the District develops alternative management strategies/facilities. As a long-term strategy, this alternative is dependent on the District having adequate merchant facility (or similar) options during the wet weather months.
- Offsite storage (modified status quo, Alternative 0A) would provide the District with a wet weather management strategy and would maximize biosolids land application. It is recommended that this alternative be further considered in the biosolids roadmap to confirm the timing and triggers for offsite storage.
- Merchant facilities (Alternative 2) should be further considered as an interim solution and the alternative carried forward into roadmap development. Note that this strategy assumes that the District is proactively encouraging the development of merchant facilities through industry outreach and the prospect of long-term tonnage commitments.
- Thermal dryer (Alternative 3) is the recommended placeholder, post-digestion technology. As the biosolids roadmap is developed, it is recommended that the timing and phasing of a thermal drying facility be considered. Because several other post-digestion technologies offer similar NPVs and non-economic scores, it is recommended that Lystek (Alternative 4) and pyrolysis (Alternative 5) continue to be monitored by the District. As the District further develops a post-digestion facility, these alternative technologies should be revisited to confirm that thermal drying is the optimal solution.
- As the roadmap is developed, biogas production and prioritization should be confirmed and coordinated with the District's development of the biogas utilization roadmap and the potential reduction in R2 waste streams as it relates to biogas production.

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CHAPTER 7 - REFERENCES

40 Code of Federal Regulations Section 503, 2020.

Brown and Caldwell, C30: Market Assessment, March 2021.

Brown and Caldwell, C60: Plant-Wide Process Model, August 2021.

Brown and Caldwell, C70: Existing Plant Capacity, August 2021.

Carollo Engineers, Bay Area Biosolids Coalition: 2018 Project Development and Evaluation, May 2019.

Carollo Engineers, C50: Evaluation Criteria, March 2021.

East Bay Municipal Utility District, MWWTP Wastewater System Overview, May 2019.

East Bay Municipal Utility District, MWWTP Existing Performance and Preliminary Capacity Assessment, February 2020.

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APPENDIX A – ALTERNATIVES DEVELOPMENT

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Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan

April 30, 2020

EBMUD

Alternatives Development: Biosolids Workshop No. 2

1

Agenda

- Workshop Objectives
- Biosolids Management Alternatives
  - Summary of Alternatives
  - Review of Results
  - Recommendations
- Discussion of Details
- Next Steps

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Workshop Objectives

- Evaluate **12** alternatives (**7 nutrient** removal and **5 solids** alternatives)
- Select up to **2 nutrient** and **2 solids** stream alternatives to carry forward for development of a phasing plan

3

Overview of Biosolids Management Alternatives

4

Biosolids Endpoint

Continue to Beneficially Use Biosolids – Winter Months

Provide a Path to Produce a Class A Product

Current Biosolids Management

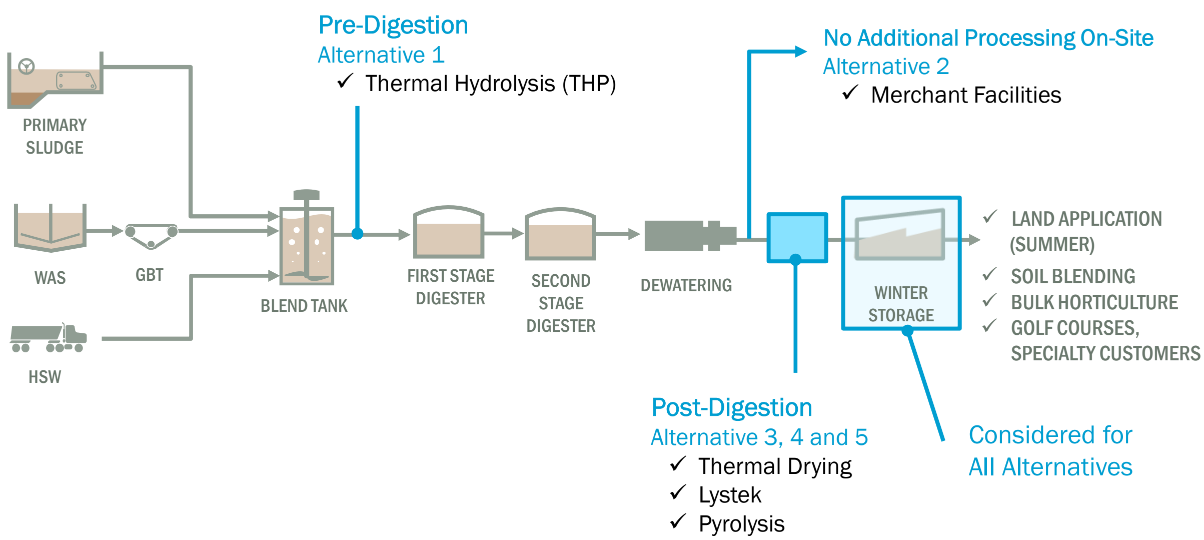
- Land Application
- Merchant Facilities (Class A)
- Landfill – ADC

Future Biosolids Management

- Land Application
- Merchant Facilities (Class A)
- Soil/Fertilizer Blending
- Horticulture & Specialty Markets

5

Overview of Alternatives



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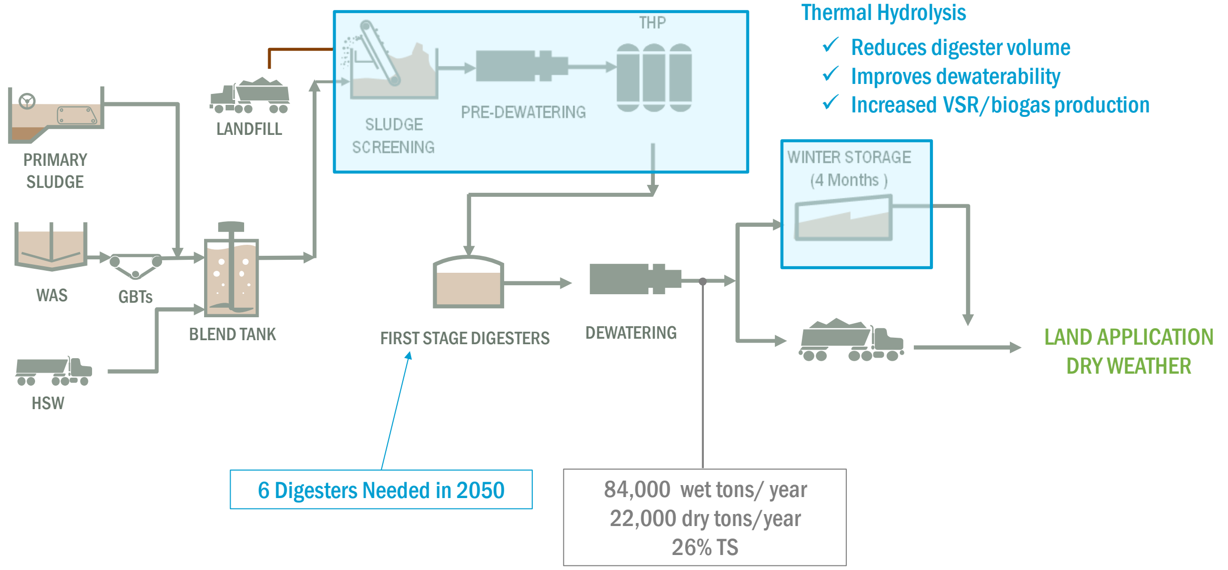
Alternative 1 – Pre-Digestion, Thermal Hydrolysis (THP)



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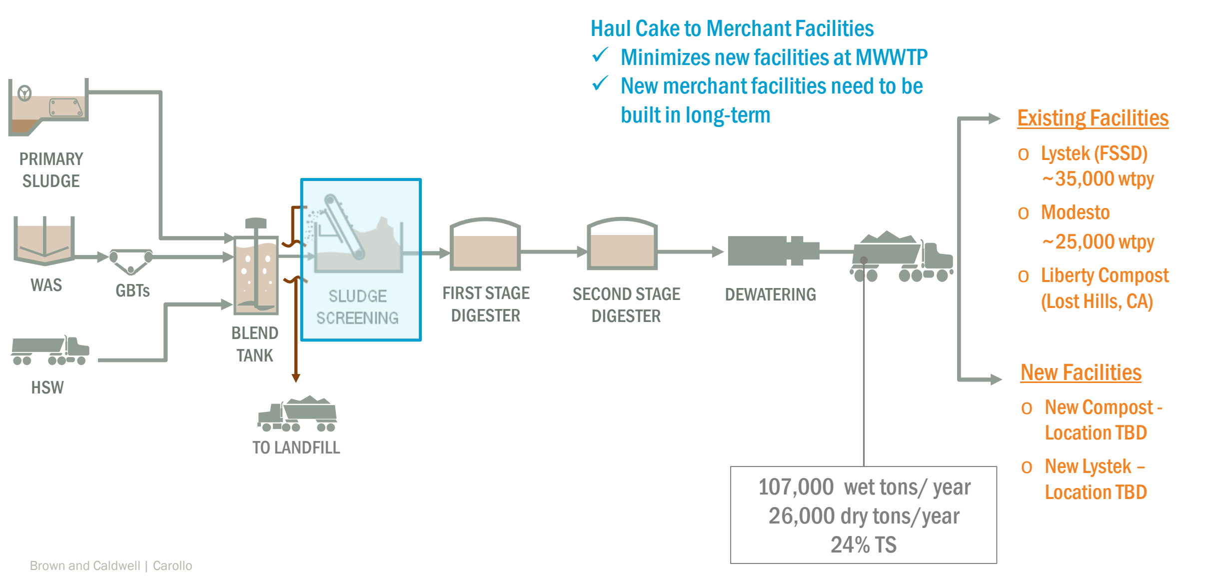
Alternative 2 – Post-Digestion, Merchant Facilities



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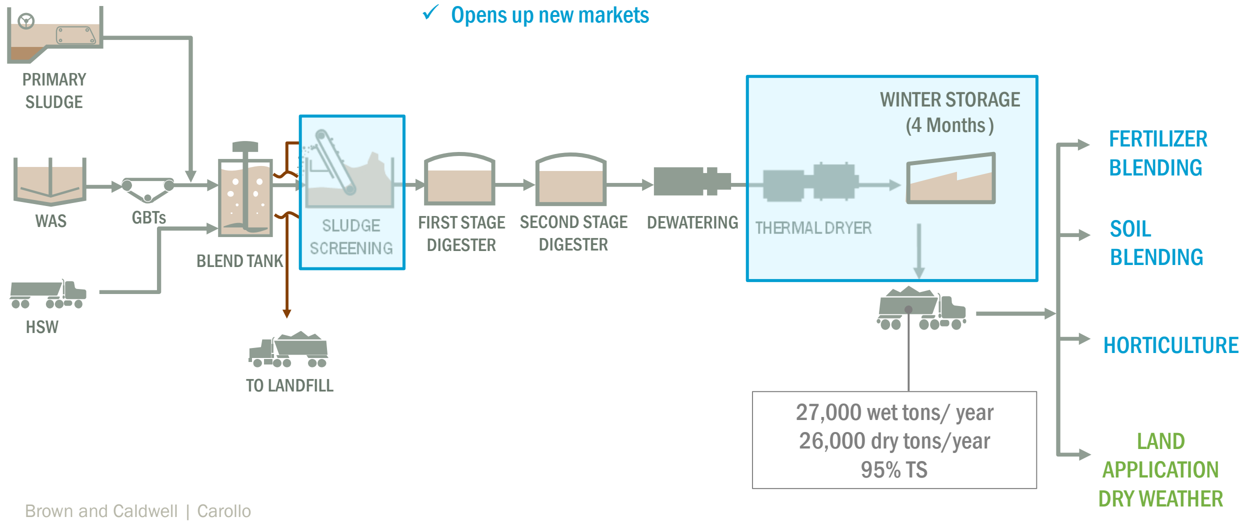
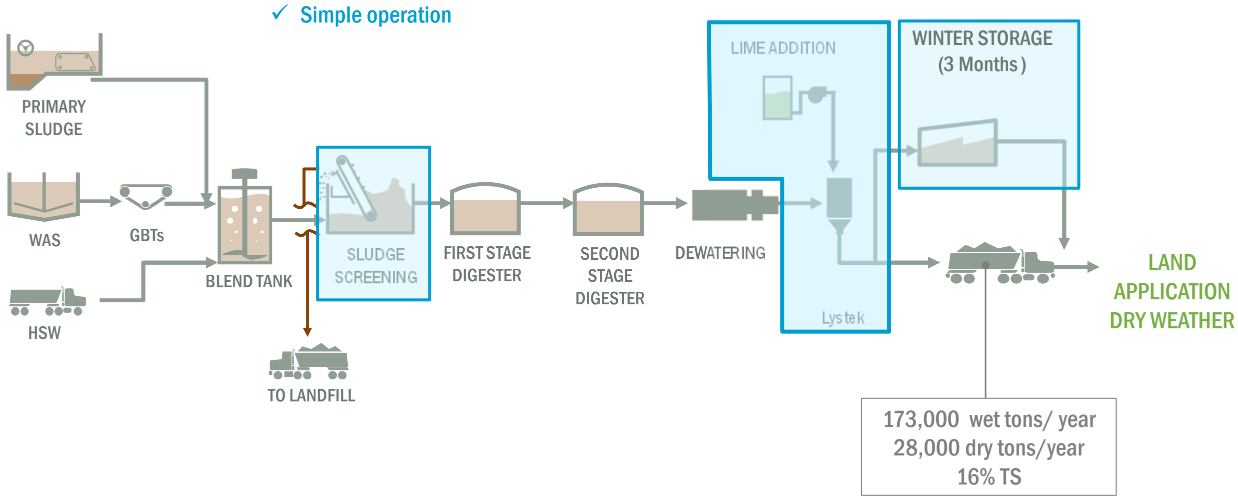
Alternative 3 – Post-Digestion, Thermal Drying

Thermal Drying
- ✓ Volume reduction
- ✓ Opens up new markets



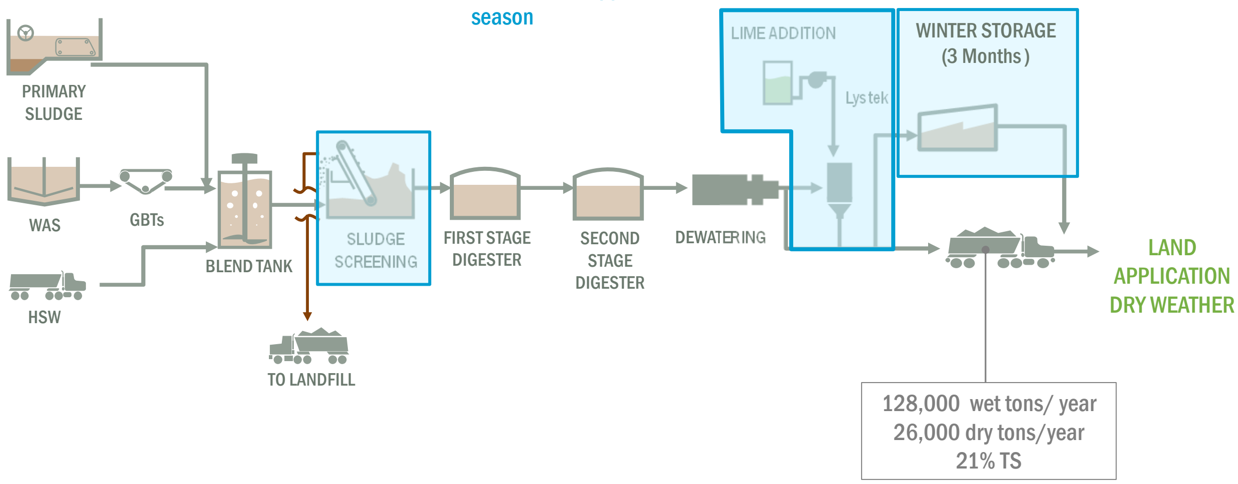
Alternative 4A – Post-Digestion, 100% Lystek

- ✓ Extends land application season
- ✓ Simple operation



Alternative 4B– Post-Digestion, Lystek Winter Operation Only

Winter Only Operation
- ✓ Extends land application season



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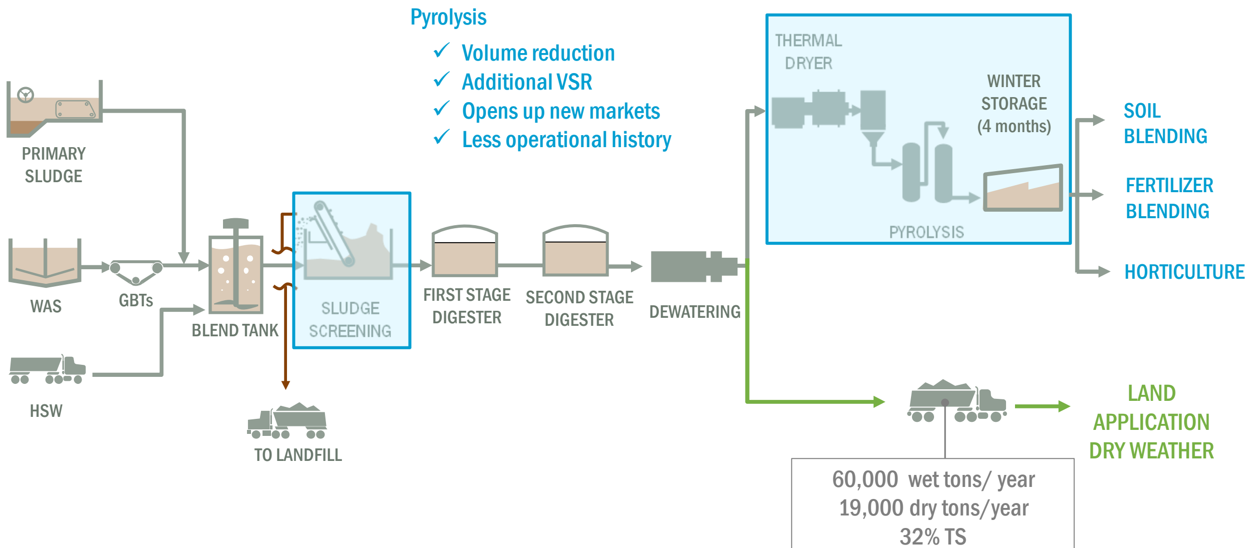
Alternative 5 – Post-Digestion, Pyrolysis (50%)

Pyrolysis
- ✓ Volume reduction
- ✓ Additional VSR
- ✓ Opens up new markets
- ✓ Less operational history



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Summary of Results

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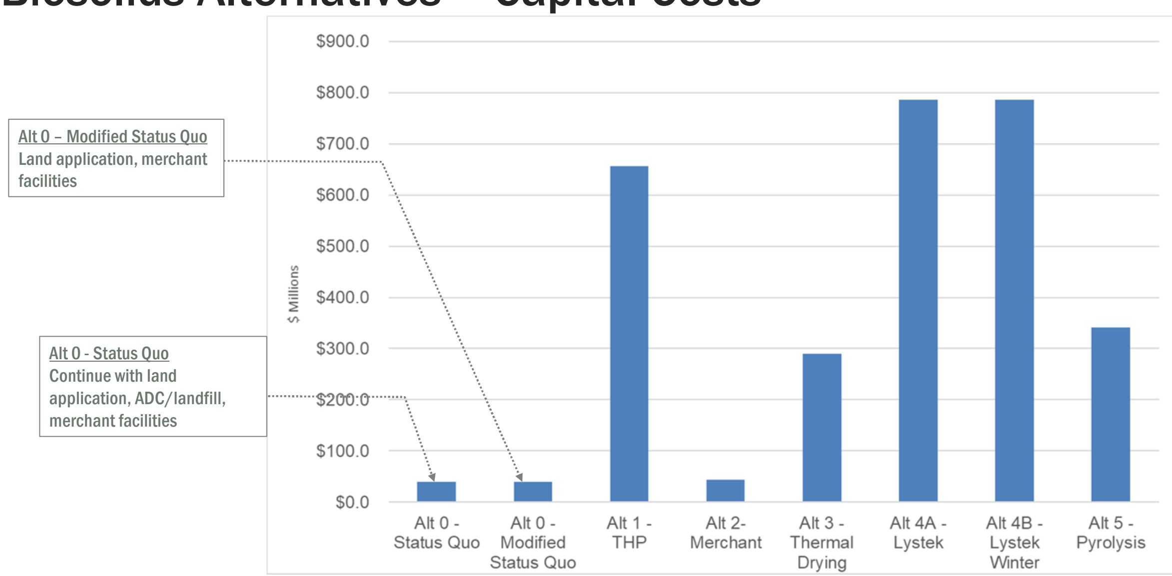
Biosolids Alternatives – Capital Costs



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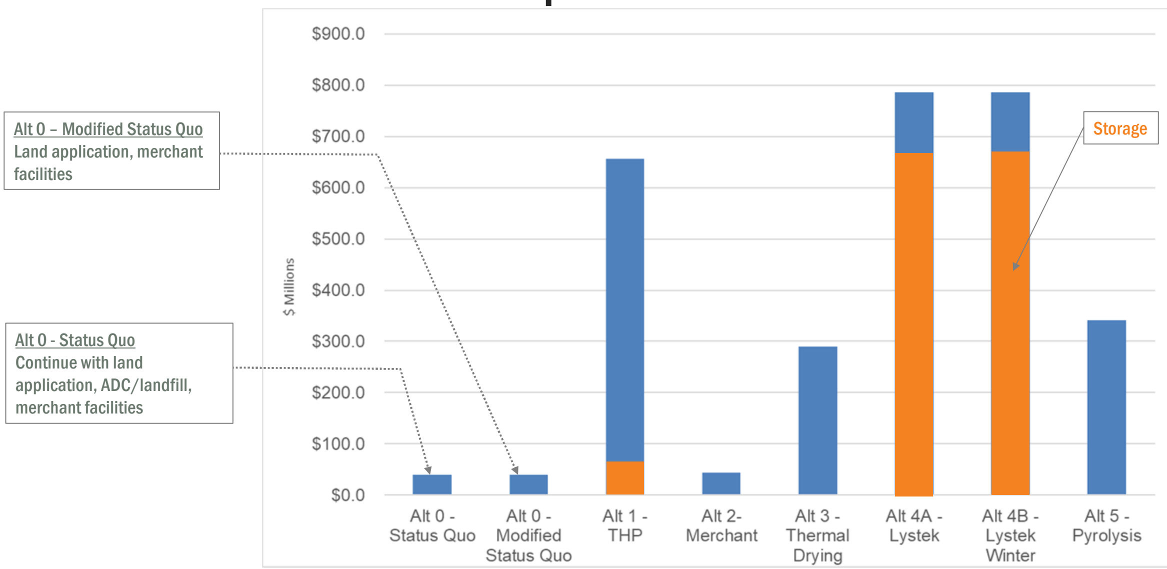
Biosolids Alternatives – Capital Costs



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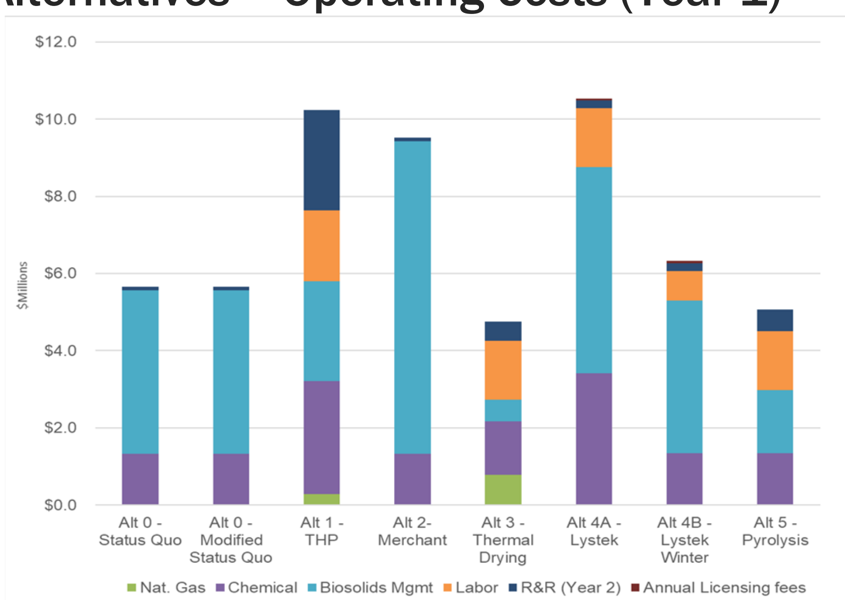
Biosolids Alternatives – Operating Costs (Year 1)



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Factors Influencing Management Costs

- Regulatory:
  - E-logs law effective in 2017 has increased trucking costs across the country.
  - SB 1383 triggers a need for expanded wet weather outlets for utilities; compliance begins in 2022
- Landfill Capacity:
  - Many landfills have limited biosolids to 10% of daily throughput
  - Landfills are currently needed to meet Bay Area wet weather demands
- Competition:
  - San Jose's biosolids enter the market in 2023 (122,000 wet tons/year)

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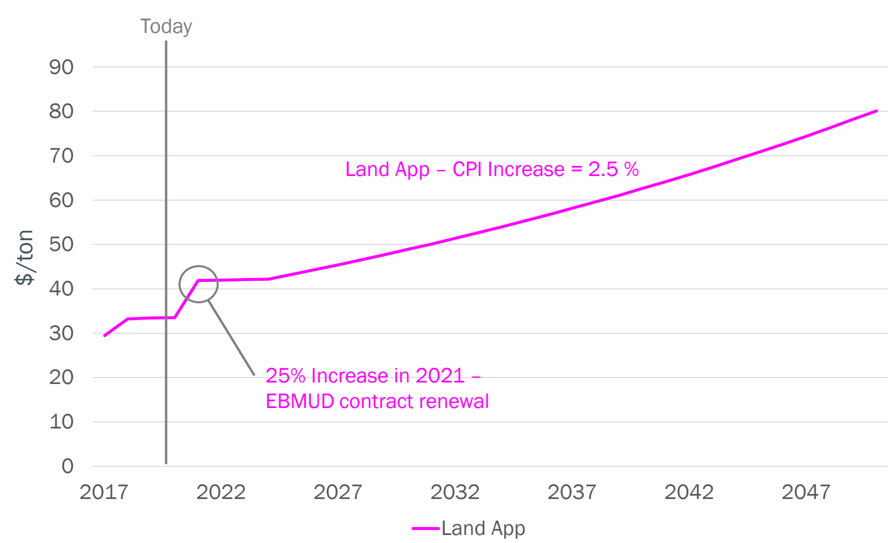
Land Application Trend



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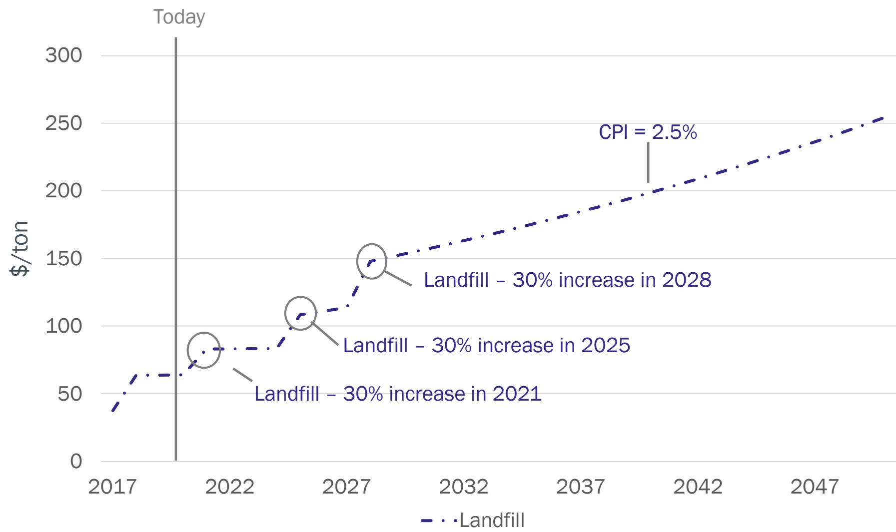
Landfill ADC Trend



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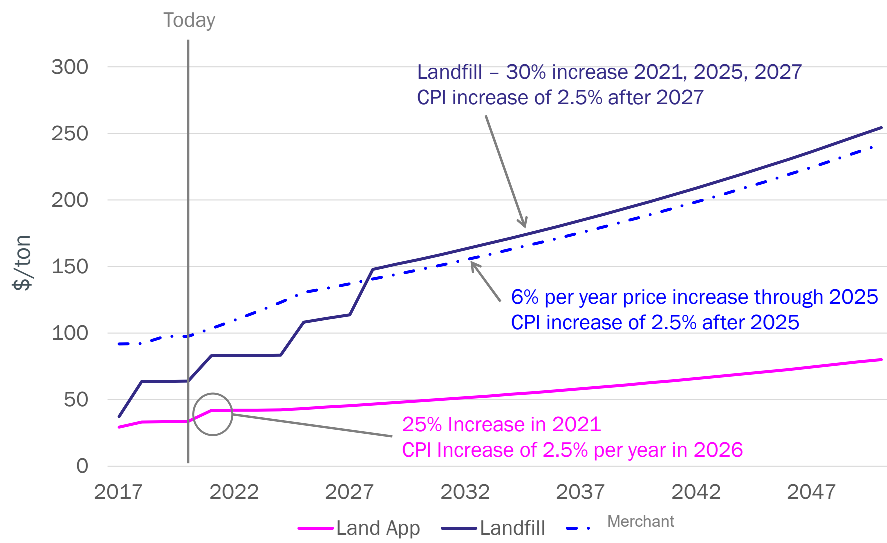
Biosolids Management Price Trends



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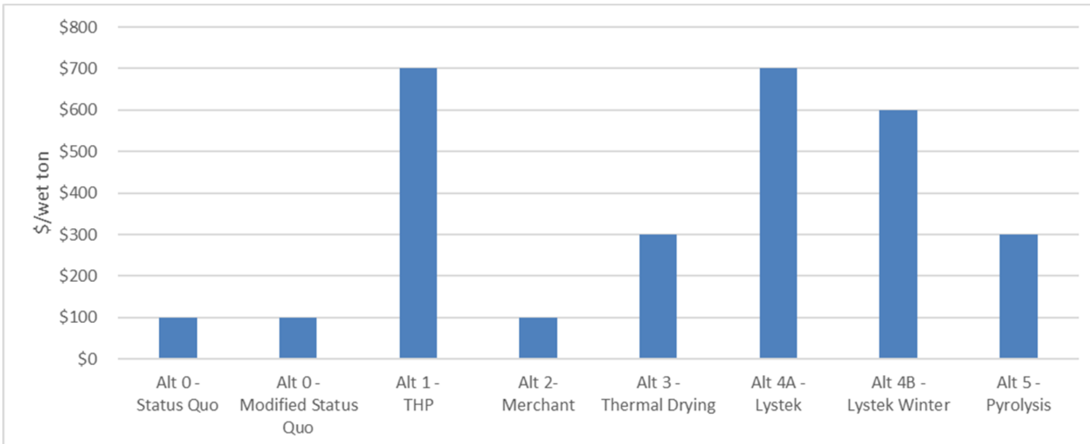
Biosolids Alternatives – Unit Costs ($/wet ton)



*Unit costs = amortized capital + operating costs – revenue / wet tons of biosolids per year

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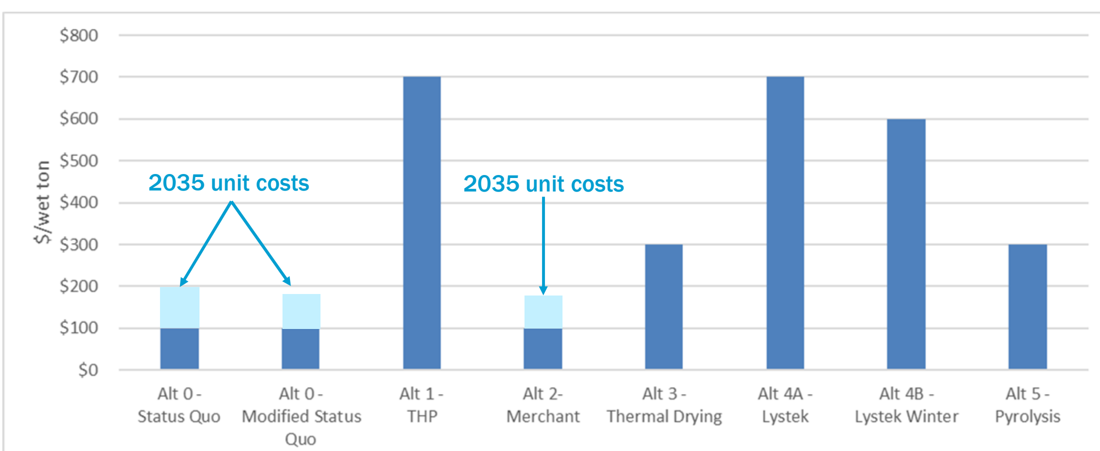
Biosolids Alternatives – Unit Costs ($/wet ton)



*Unit costs = amortized capital + operating costs – revenue / wet tons of biosolids per year

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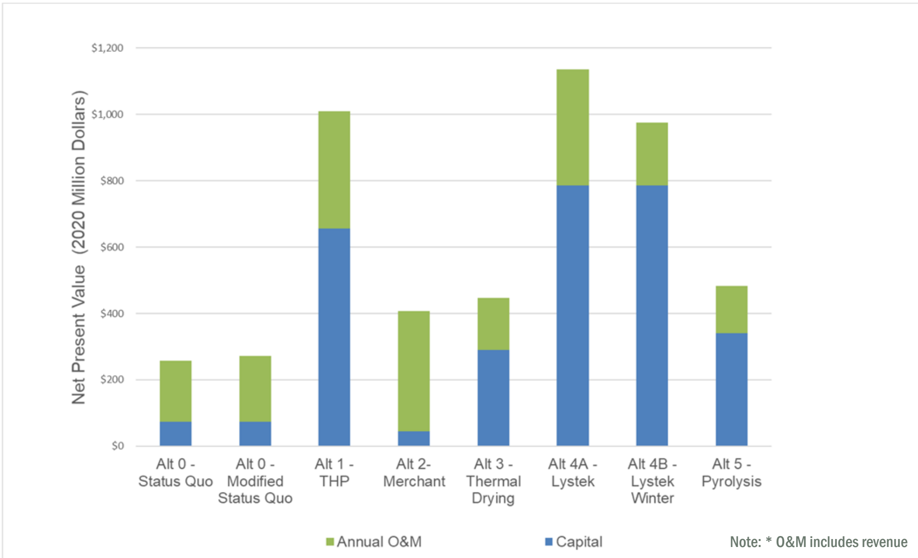
Biosolids Alternatives – Net Present Value



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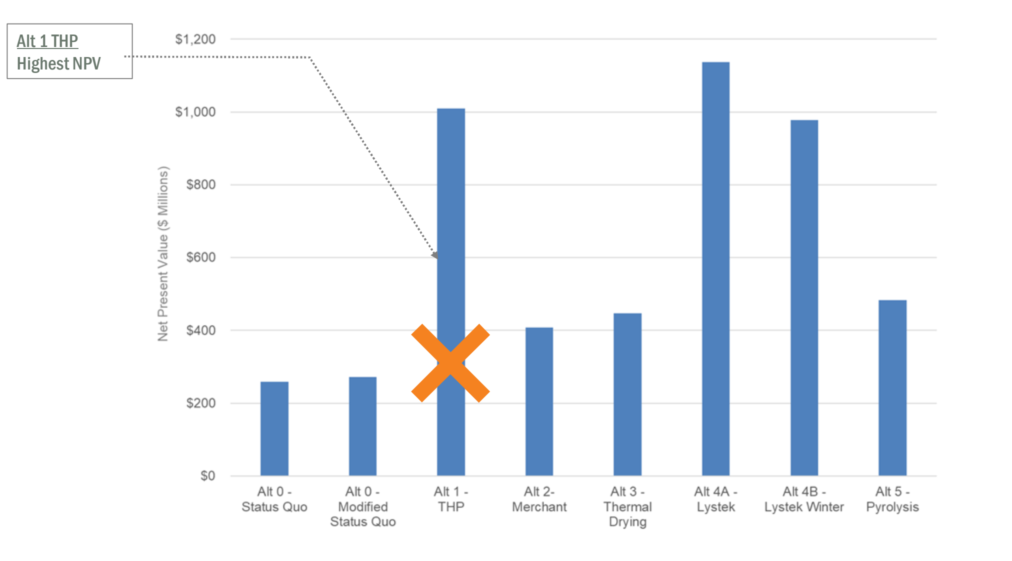
Biosolids Alternatives – Net Present Value



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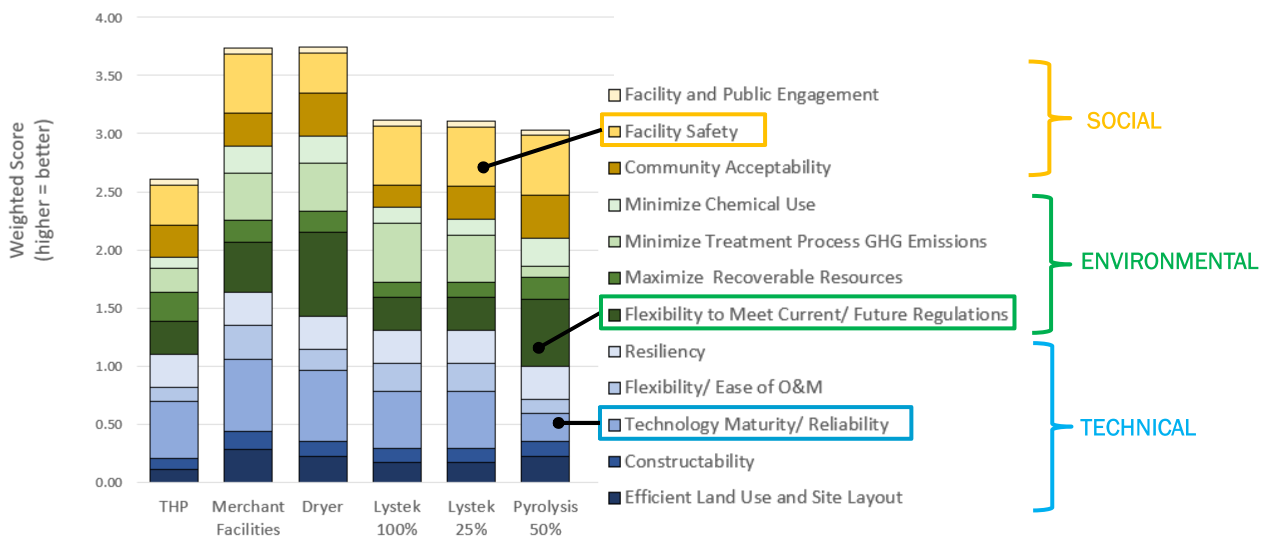
Biosolids Alternatives - Non-Economic Results



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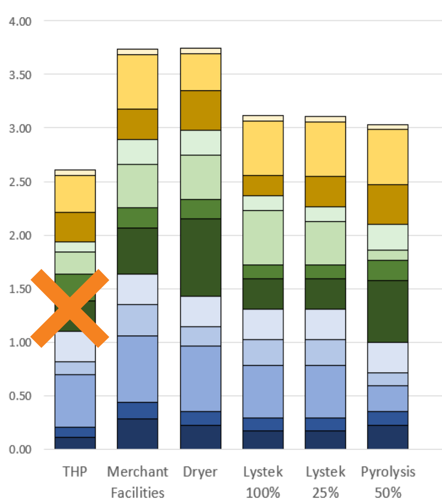
Biosolids Alternatives - Non-Economic Results



Facility Safety

- Scores ranged based on chemical usage
- All chemical facilities will be designed to safety standards

	Score	Notes
Alt 1 – THP	2	• High temperature and pressure operating system
Alt 2 – Merchant	3	• No change from existing system
Alt 3 – Thermal Dryer	2	• Risk of fire with pellet storage
Alt 4A and 4B – Lystek	3	• High temperature and high chemical use
Alt 5 - Pyrolysis	3	• Unknown risks with system operation

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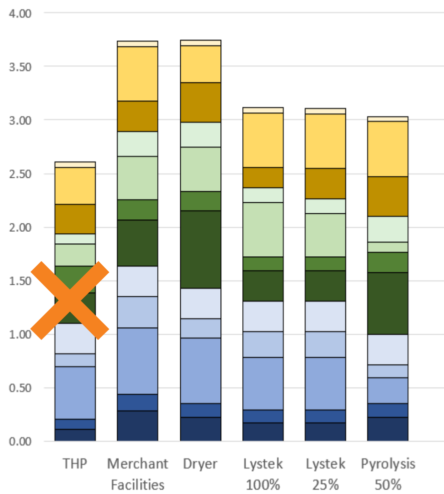
Biosolids Alternatives - Non-Economic Results



Flexibility to Meet Current and Future Regulations

- Scores ranged based on ease of phasing improvements to meet increasingly stringent limits

	Score	Notes
Alt 1 – THP	2	• Limited new markets
Alt 2 – Merchant	3	• Dependent on facility for regulatory compliance and marketing of end product
Alt 3 – Thermal Dryer	5	• Additional markets for beneficial use; PFAS levels likely to be lower than other technologies
Alt 4A and 4B – Lystek	2	• Limited markets other than land application; no known PFAS reduction
Alt 5 - Pyrolysis	4	• Provides additional markets for beneficial use; potential for PFAS reduction

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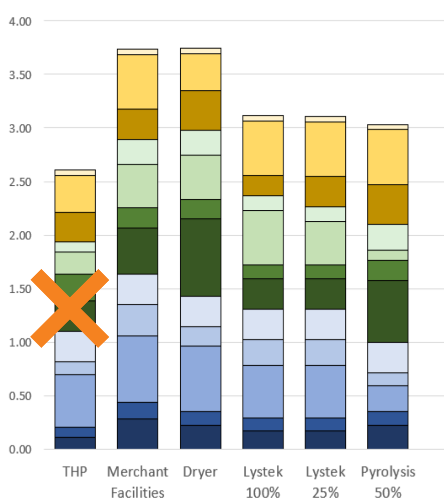
Biosolids Alternatives - Non-Economic Results



Technology Maturity/Reliability

- Scores ranged based on number/size of installations and overall reliability

	Score	Notes
Alt 1 – THP	4	• Higher on S-curve, most installations are in Europe
Alt 2 – Merchant	5	• No technology at MWWTP
Alt 3 – Thermal Dryer	5	• Established in US
Alt 4A and 4B – Lystek	4	• Becoming established - 10 operating facilities in N. America
Alt 5 - Pyrolysis	2	• Emerging, limited operating facilities at larger capacity

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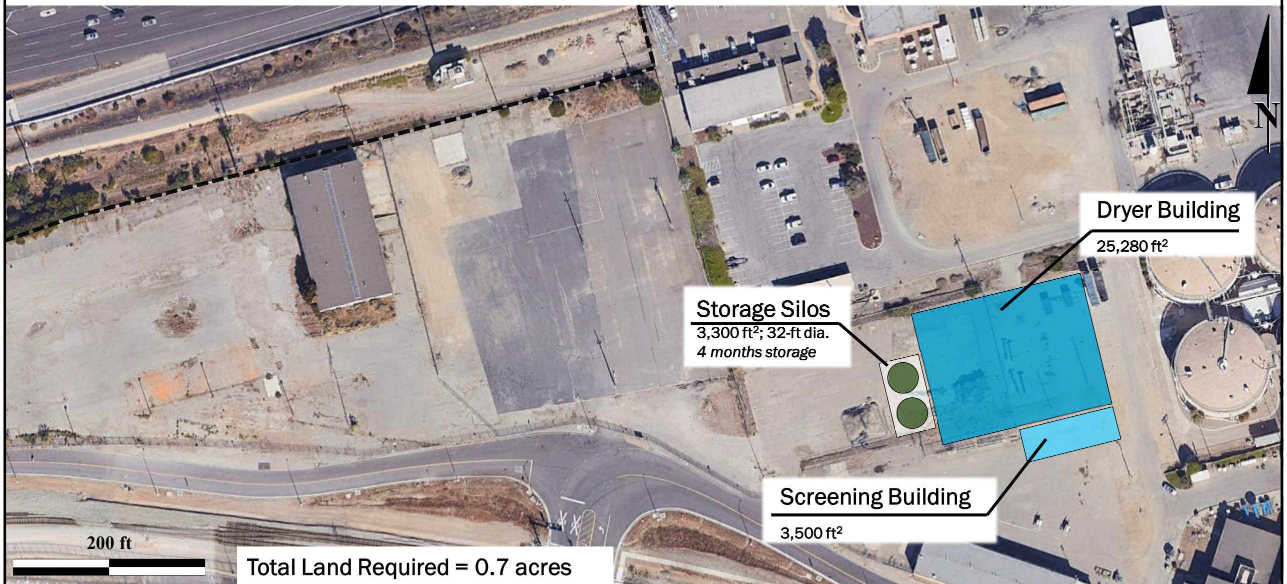
GHG Emissions For Biosolids Alternatives

- Sources of GHG emissions
  - Electrical energy consumed
  - Natural gas purchased
  - Chemical production (Scope 3)
  - Biosolids hauling (Scope 3)
- GHG Offsets
  - Avoided purchased power (cogeneration)
  - Carbon sequestration (Scope 3)
  - Offsetting synthetic fertilizer N (Scope 3)
  - Offsetting synthetic fertilizer P (Scope 3)

GHG Emissions Results

	Alt 0 – Status Quo	Alt 1 – THP	Alt 2 – Merchant	Alt 3 – Thermal Drying	Alt 4A – 100% Lystek	Alt 4B – 25% Lystek	Alt 5 - Pyrolysis
Total Emissions (metric tons CO2e/y)	14,900	15,100	7,800	12,600	7,300	6,200	7,500
Total Offsets (metric tons CO2e/y)	-15,000	-14,000	-16,100	-14,800	-16,900	-16,000	-12,800
Net Emissions (metric tons CO2e/y)	-100	1,100	-8,300	-2,200	-9,600	-9,800	-5,300
Score	NA	1.0	4.0	3.0	5.0	5.0	2.0
Notes	Landfill/ADC	High energy and natural gas usage; High carbon sequestration & fertilizer value; Higher polymer use	Minimal natural gas use; High carbon sequestration & fertilizer value	Highest natural gas usage; High carbon sequestration & fertilizer value	Higher carbon sequestration & fertilizer value; Lower polymer use and caustic	Higher carbon sequestration & fertilizer value; Lower polymer use and caustic	Lower carbon sequestration & fertilizer value

Alternative 3 – Thermal Drying



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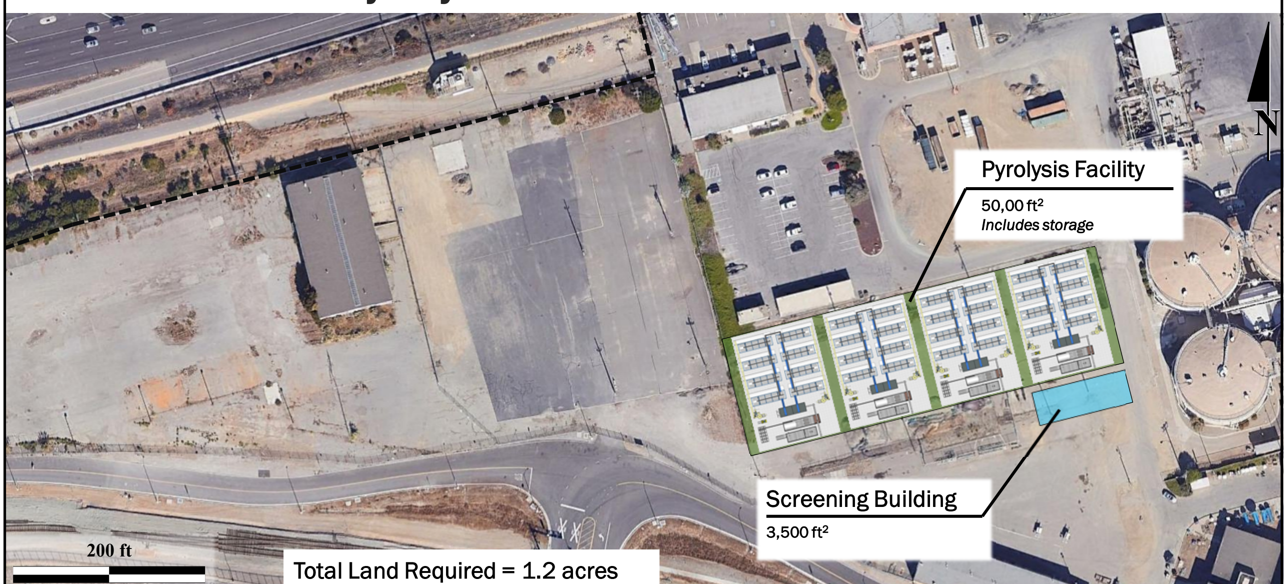
Alternative 5 – Pyrolysis



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Conclusions

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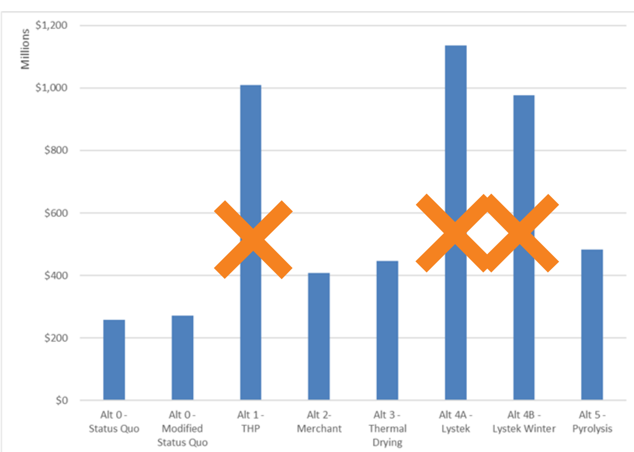
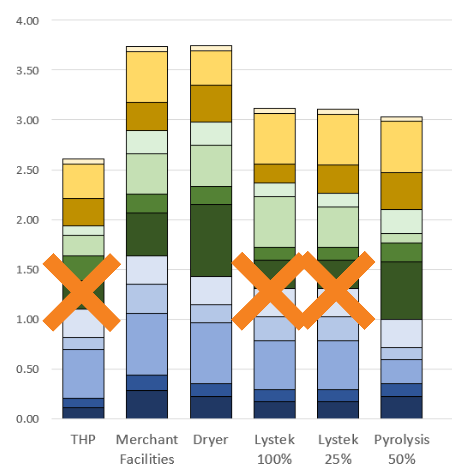
Summary of Alternatives

Net Present Value



Non-Economic Scoring



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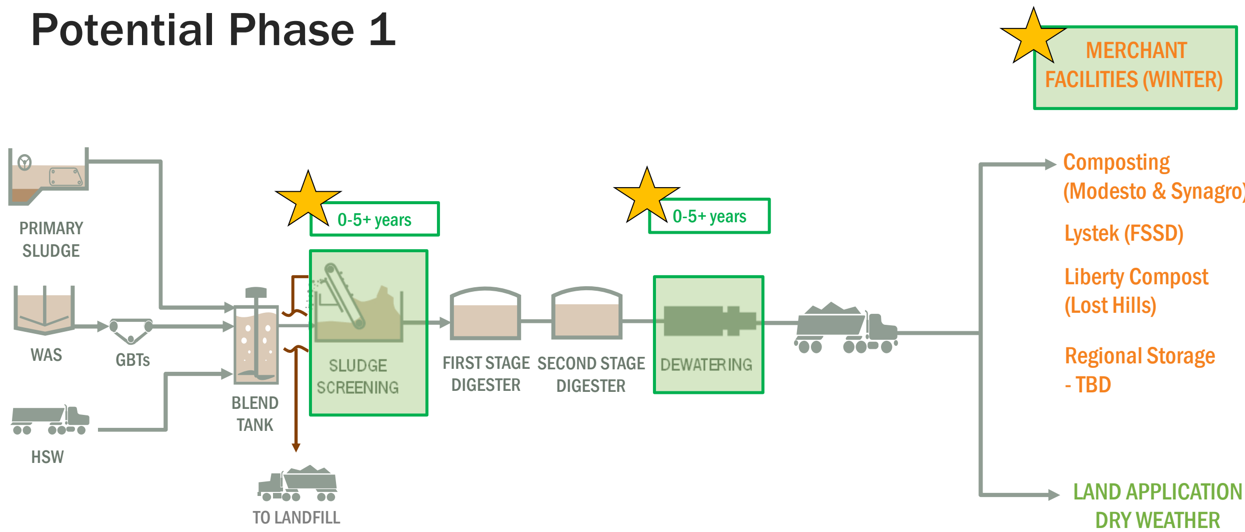
Potential Phase 1



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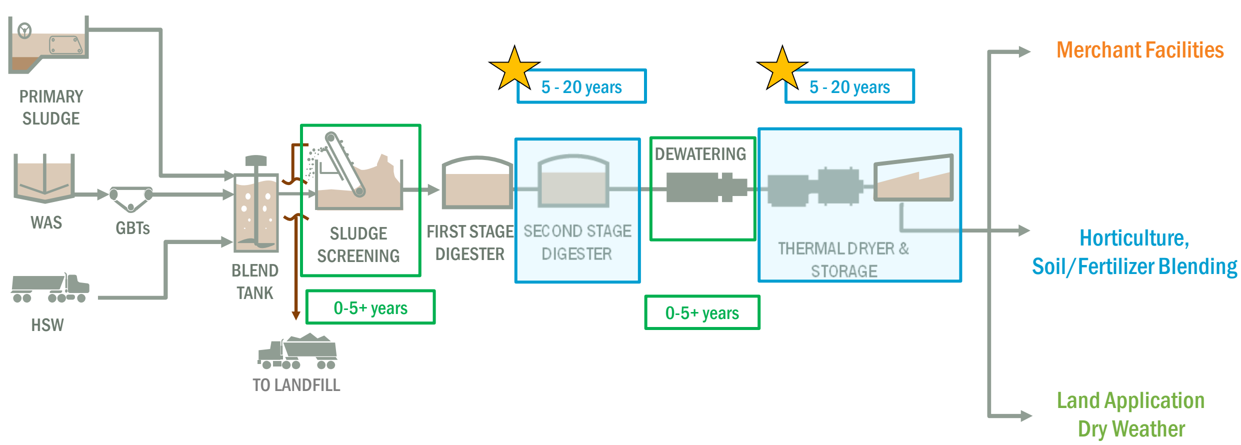
Potential Phase 2



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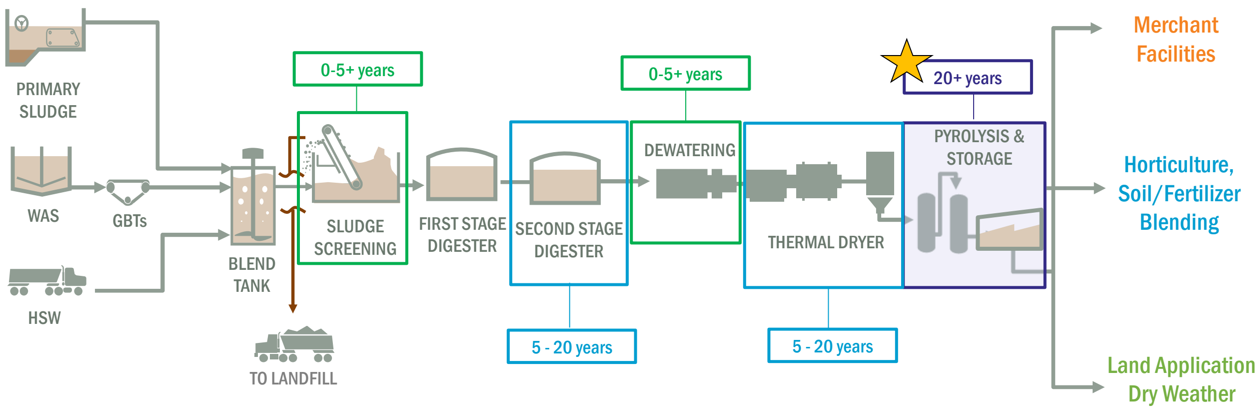
Potential Phase 3



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Thank you.
Questions?

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Biosolids Management Alternatives - Details

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Details on Biosolids Management Trends

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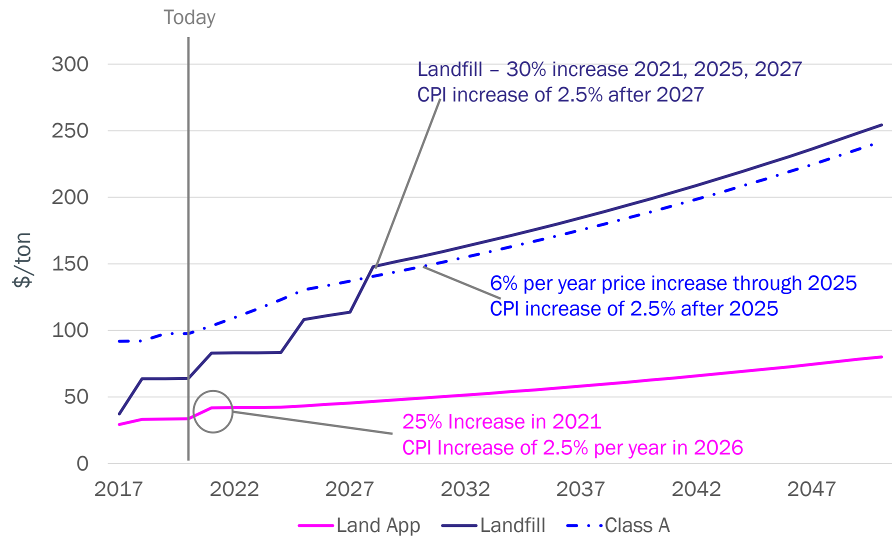
Potential Biosolids Management Price Trends



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Factors Influencing Management Costs

- Regulatory:
  - E-logs law effective in 2017 has increased trucking costs across the country.
  - SB 1383 triggers a need for expanded wet weather outlets for utilities; compliance begins in 2022
- Landfill Capacity:
  - Many landfills have limited biosolids to 10% of daily throughput
  - Landfills are currently needed to meet Bay Area wet weather demands
- Competition:
  - San Jose's biosolids enter the market in 2023 (122,000 wet tons/year)

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Anticipated and Observed Trends

- 30-50% jump in price upon renewal has been observed in other constrained markets (e.g. NY, New England, GA)
- Santa Rosa recent bids for merchant facilities:
  - Synagro ~$95/wet ton
  - Lystek ~$115/wet ton
- Anticipate price increases in both dry and wet weather outlets when San Jose enters the market – impacts will be more severe on already limited wet weather outlets
- Landfills will continue to ratchet down quantities and increase prices – biosolids not a desirable material to manage
- Prices will stabilize as new capacity is developed

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Land Application

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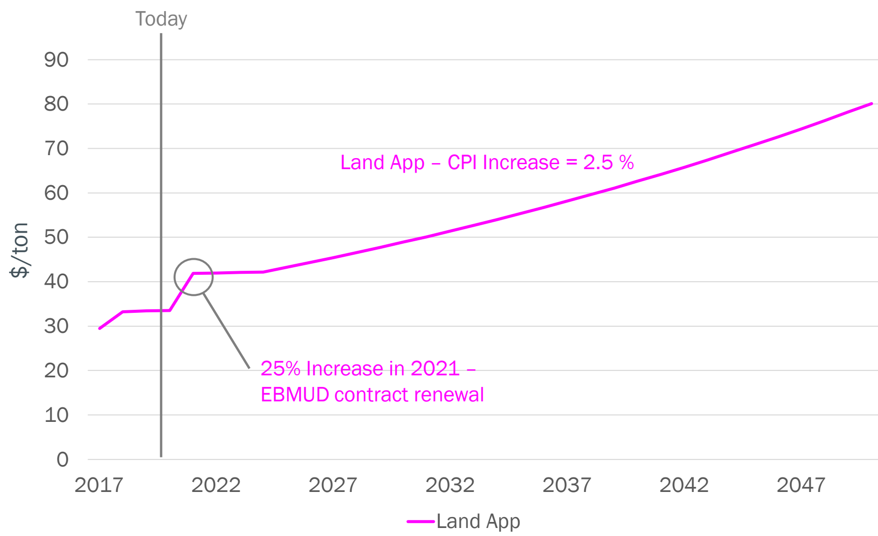
Land Application Trend



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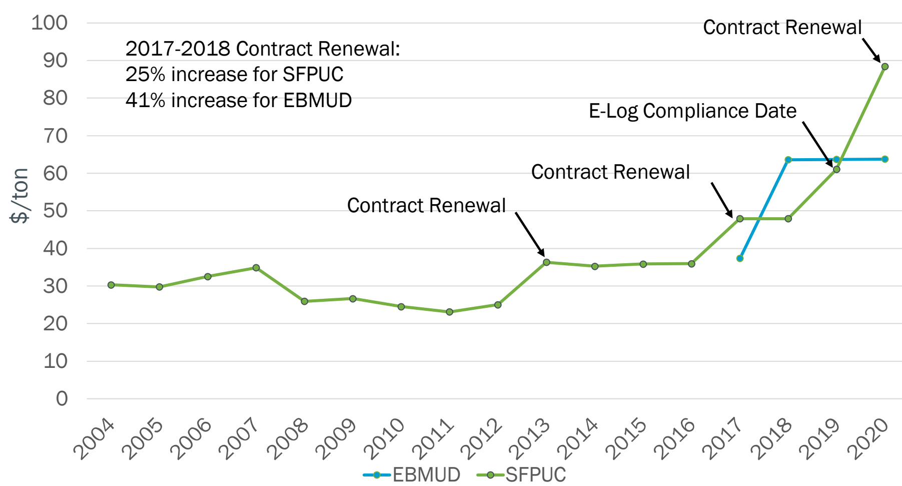
Landfill -ADC



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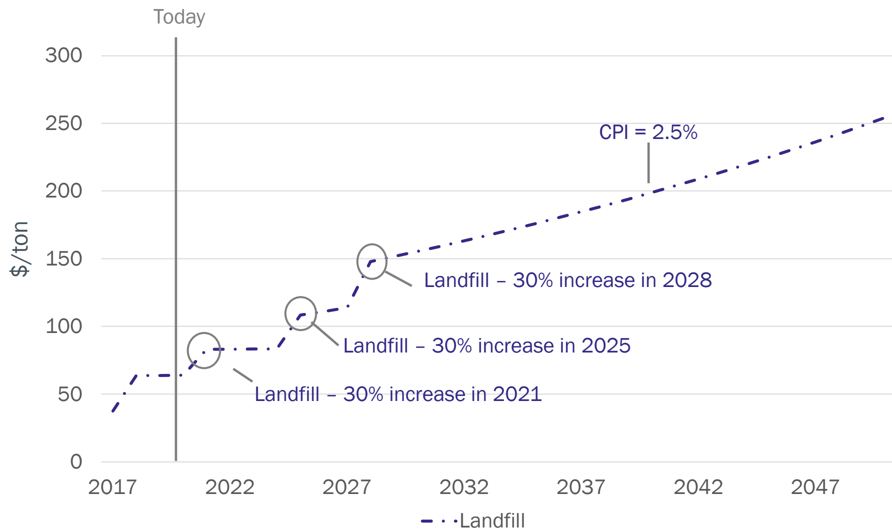
Landfill ADC Trend



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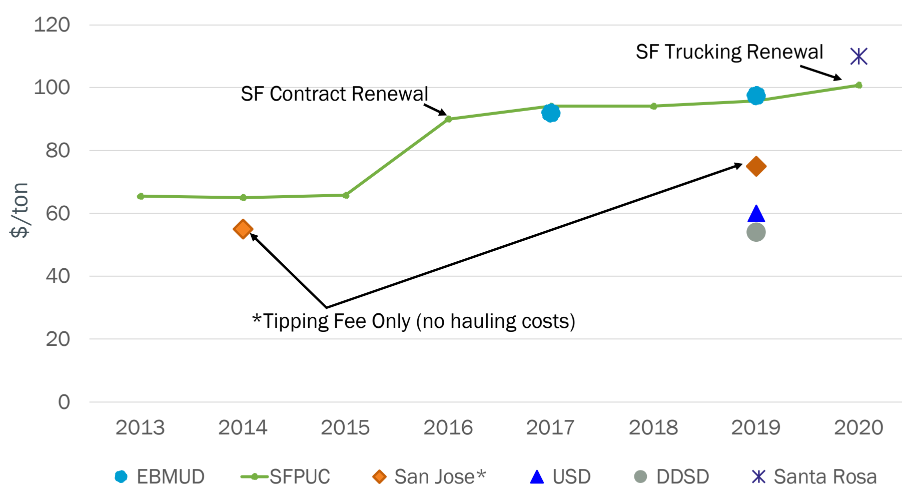
Class A Merchant Facility



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Status Quo

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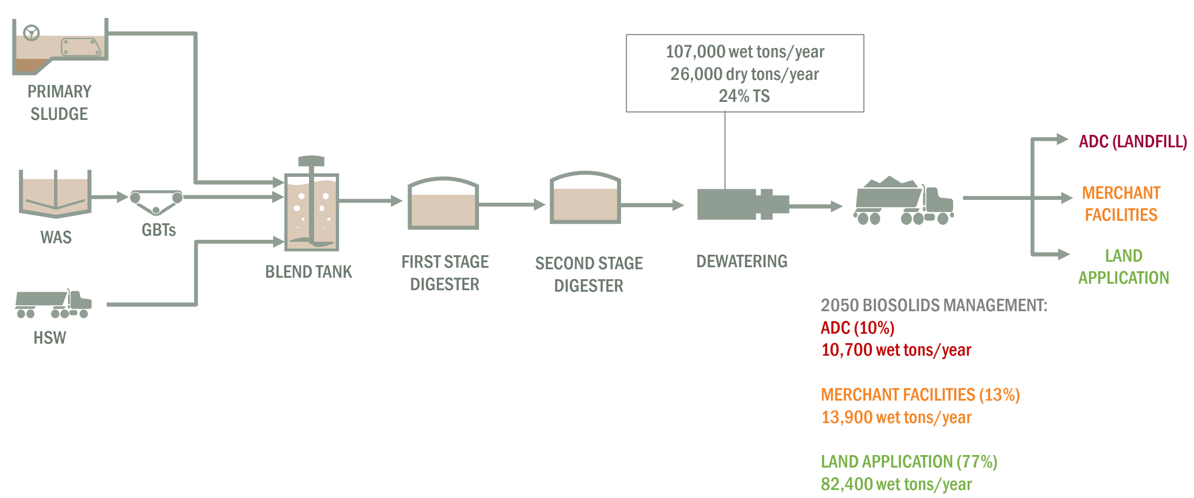
Alternative 0 –Status Quo



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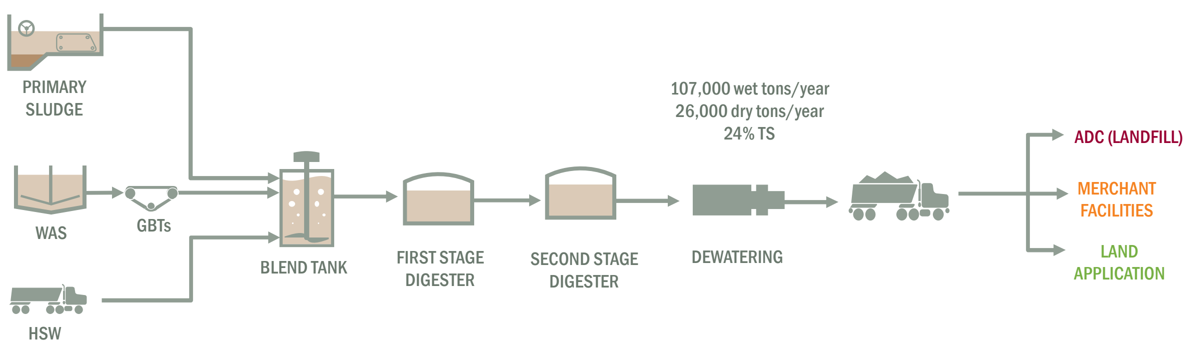
Key Considerations

- Landfill – ADC is unreliable outlet in the winter months
- Storage of cake at MWWTP requires significant land and capital
- Land application is reliable at this time during the dry months (summer)
- Factors that may impact land application costs and reliability:
  - PFAS regulations
  - Fuel costs

Alternative 0 – Modified Status Quo



2025 BIOSOLIDS MANAGEMENT:
ADC (10%)
7,100 wet tons/year

MERCHANT FACILITIES (13%)
9,100 wet tons/year

LAND APPLICATION (77%)
55,000 wet tons/year

2050 BIOSOLIDS MANAGEMENT:
ADC (0%)
0 wet tons/year

MERCHANT FACILITIES (30%)
32,000 wet tons/year

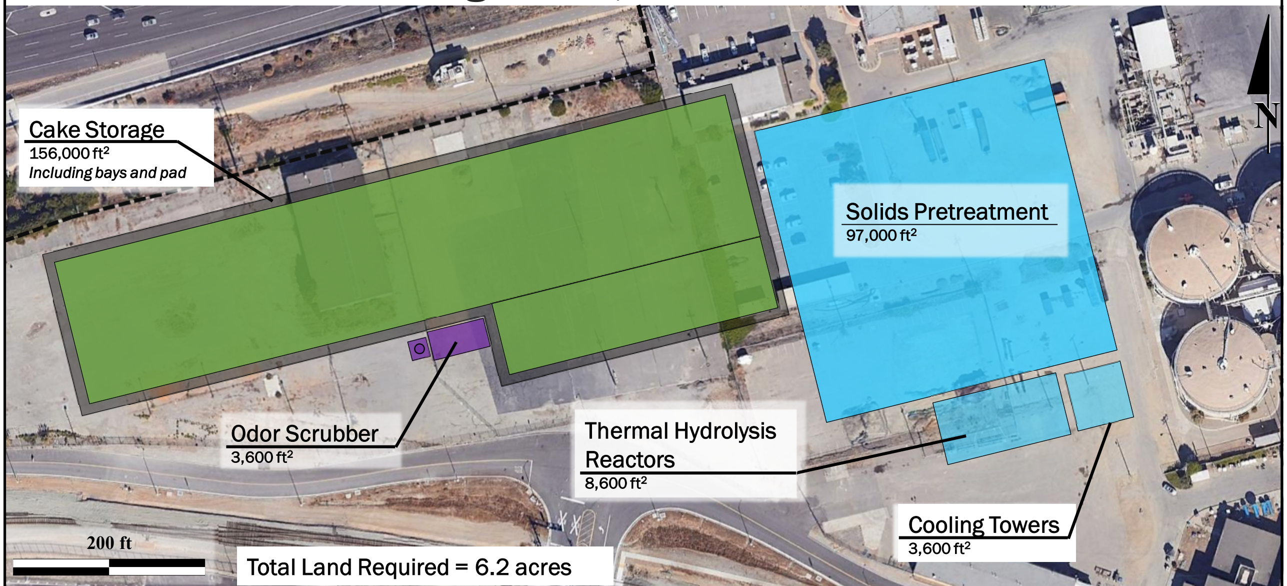
LAND APPLICATION (70%)
75,000 wet tons/ year

Status Quo and Modified Status Quo

Item	Status Quo	Modified Status Quo
New Facilities at MWWTP	Second Stage Digester Seismic Rehab	Second Stage Digester Seismic Rehab
Biosolids Storage	--	--
End Use	Land Application (82,400 wet tons/year Landfill/ADC (10,700 wet tons/year) Merchant Facilities (13,900 wet tons/year)	Land Application (75,000 wet tons/year) Merchant Facilities (32, 000 wet tons/year)
Biosolids Hauling in 2050 (trucks per day)	15 trucks per day	15 trucks per day
Revenue (Year 2050)	$1.2 M	$ 1.2 M

Alternative 1 - THP

Alternative 1 – Pre-Digestion, THP Site Plan



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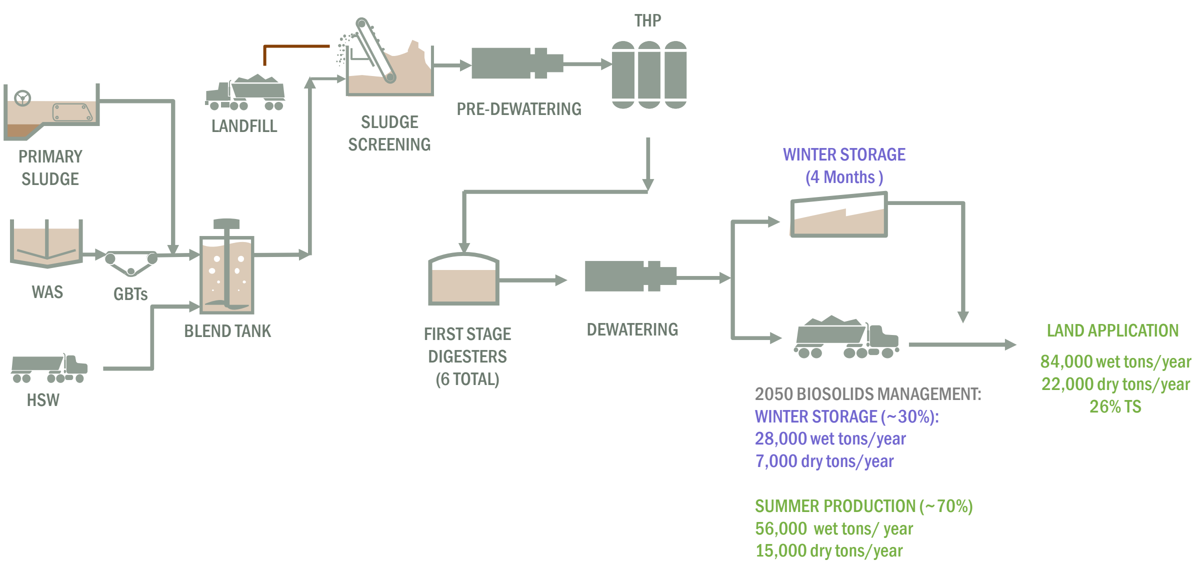
Alternative 1 – Pre-Digestion, THP



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Alt 1 – THP Key Considerations

- At 2050 loading conditions, 6 digesters are needed
  - Avoided cost for seismic retrofit of second-stage digesters
  - Additional capacity would remain for HSW, if needed

- High capital and operating costs
- Limited value and market for biosolids cake
- Storage during winter months requires significant acreage and adds significant costs

- Impact from return streams:
  - Additional 1 mg/L of non-biodegradable organic nitrogen in centrate
  - Additional ~7% ammonia load in centrate

Alternative 1 - THP

Item	Alt 1
Biosolids Storage Type	Enclosed bunker style with odor control
Biosolids Storage Land Requirements	3.6 acres (storage volume of 3,500 Mcf)
End Use In 2050	Land application (84,000 wet tons/year)
Number of Biosolids Trucks (Year 2050)	12 trucks/day
Revenue (Year 2050)	$1.1 M electricity sale
Total Land Requirements	6.2 acres

Alternative 2 – Merchant Facilities

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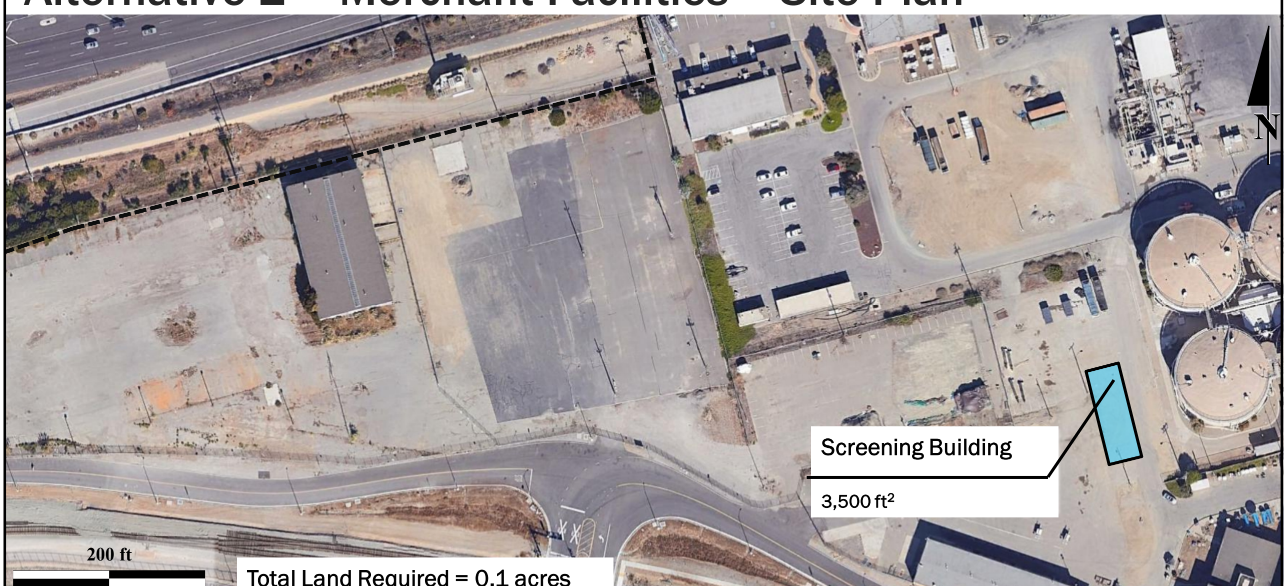
Alternative 2 – Merchant Facilities – Site Plan



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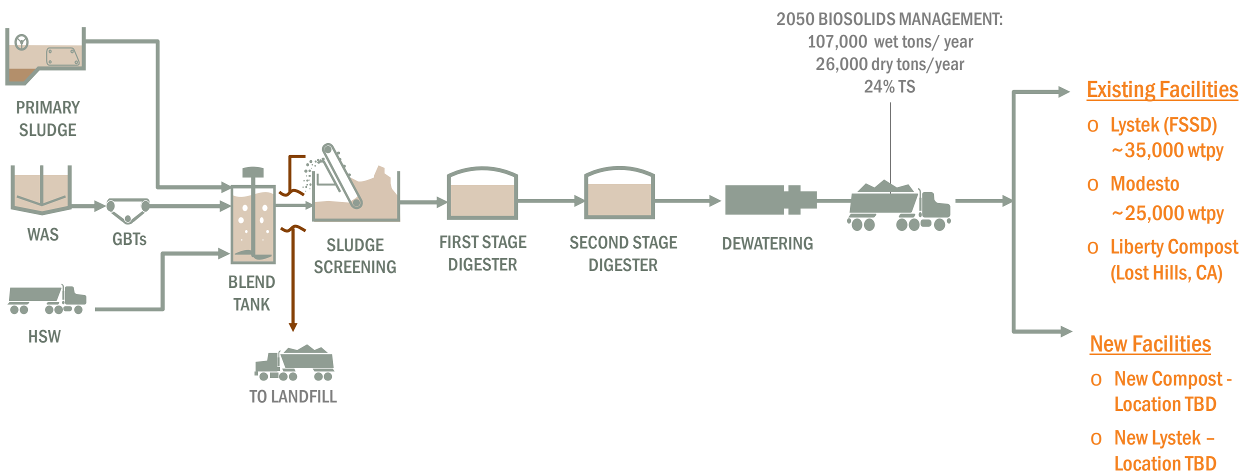
Alternative 2 – Post-Digestion, Merchant Facilities



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Alt 2 – Merchant Facilities - Key Considerations

- Maximizes land at MWWTP
- Minimal capital investment
- Long-term contracts can help control biosolids management costs
- Risk associated with:
  - Cost uncertainty,
  - Biosolids handling and future capacity, and
  - Preparation for future regulations

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Alternative 2 – Merchant Facilities

Item	Alt 2
Biosolids Storage Type	--
Biosolids Storage Land Requirements	--
End Use In 2050	107,000 wet tons/year Compost, Lystek (Land Application)
Number of Biosolids Trucks (Year 2050)	15 trucks/day
Revenue (Year 2050)	$1.2 M electricity sale
Land Requirements	0.1 acres

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Alternative 3 – Thermal Drying

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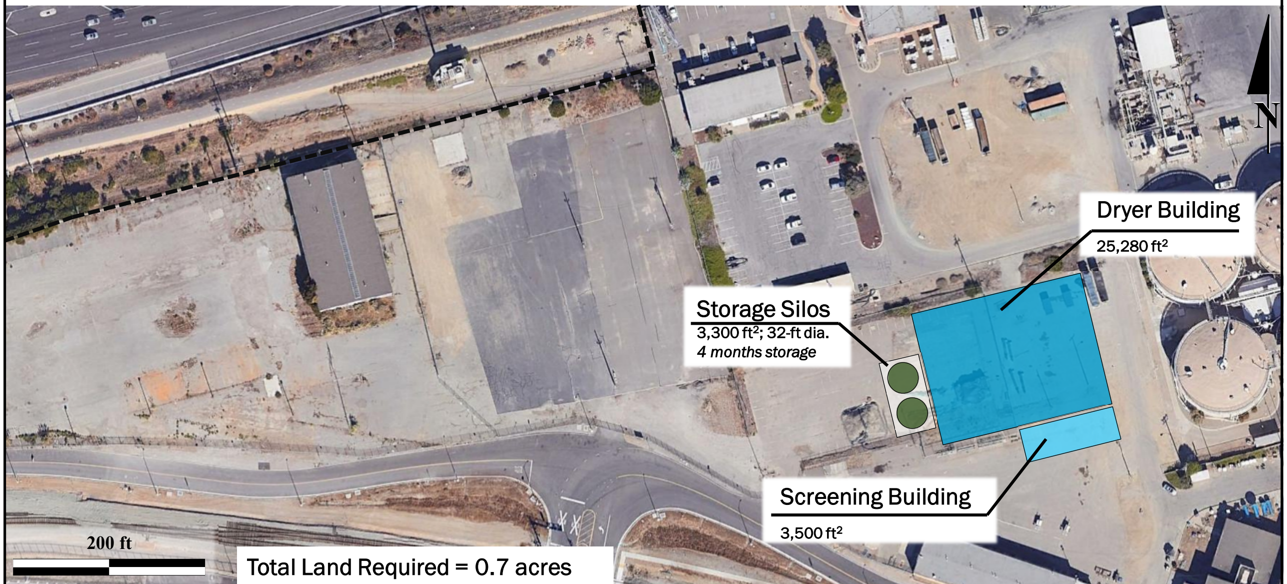
Alternative 3 – Thermal Drying



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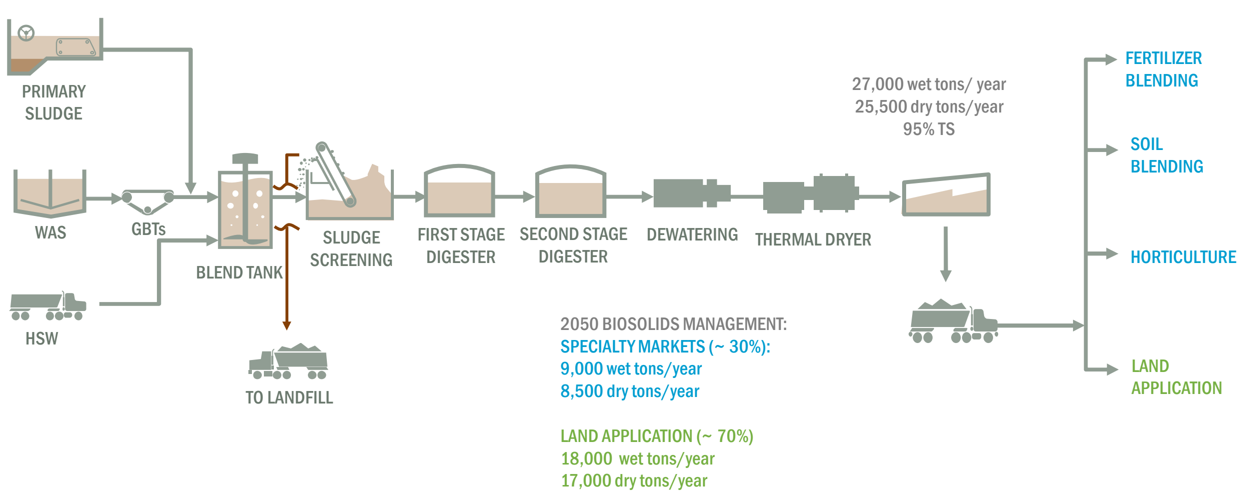
Alternative 3 – Post-Digestion, Thermal Drying



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Alternative 3- Thermal Drying Key Considerations

- Maximizes land at MWWTP
- Reduces the volume of biosolids to be managed
- Opens specialty markets for product

- New dewatering building can be constructed adjacent to thermal dryers or as another level to the building

Alternative 3 – Thermal Drying

Item	Alt 3
Biosolids Storage Type	2- 32 ft diameter silos with odor and dust control
Biosolids Storage Land Requirements	<0.1 acres
End Use In 2050	9,000 wet tons/year – specialty markets 18,000 wet tons/year – land application
Number of Biosolids Trucks In 2050	4 trucks/day
Revenue In 2050	$0.90M - electricity sale $0.1M – pellet product sales
Land Requirements	0.80 acres

Alternative 4 – Lystek

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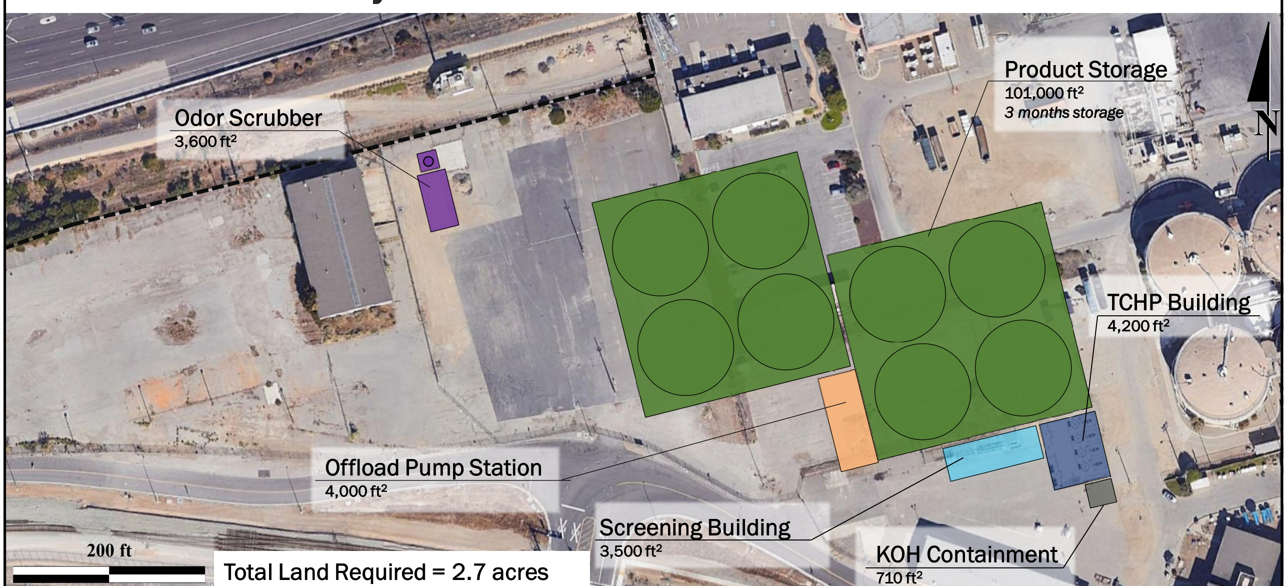
Alternative 4 – Lystek



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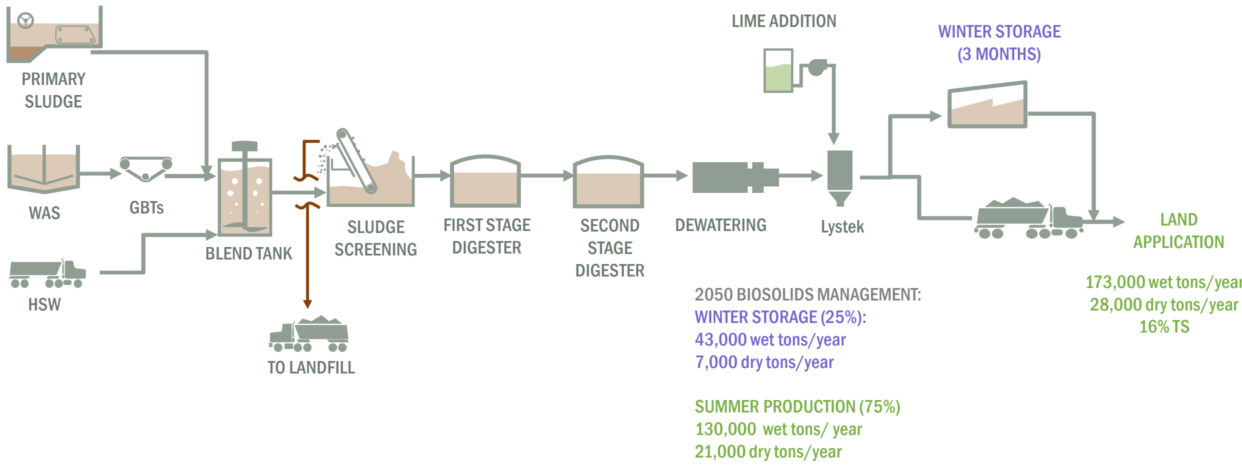
Alternative 4A – Post-Digestion, 100% Lystek



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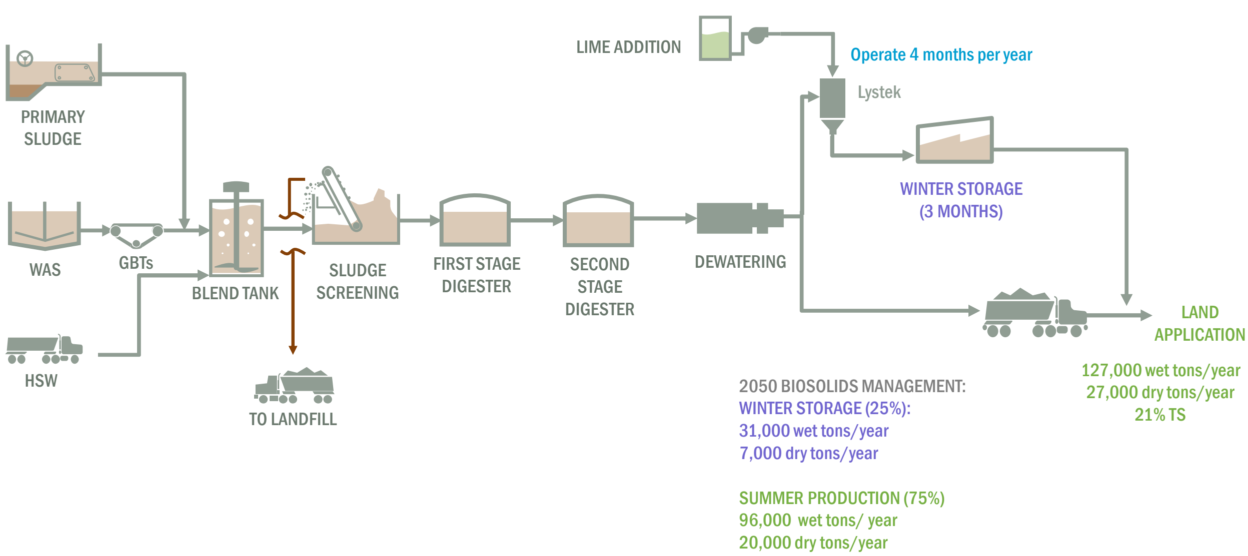
Alternative 4B –Post-Digestion, Lystek- Winter Only Operation



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Alternative 4- Lystek Key Considerations

- High capital and operating costs
  - Capital costs are driven by large volume for winter storage
- Limited value and market for biosolids cake
- Impact from return streams:
  - Sidestream ammonia load is reduced by ~ 5% due to lower solids content in cake

Alternative 4 – Lystek

Item	Alt 4A	Alt 4B Winter Only
Biosolids Storage Type	Concrete tanks (8x 100ft diameter)	Concrete tanks (8x 100ft diameter)
Biosolids Storage Land Requirements	2.3 acres	2.3 acres
End Use In 2050	173,000 wet tons/year land application	129,000 wet tons/year land application
Number of Biosolids Trucks In 2050	24 trucks/day	18 trucks/day
Revenue	$1.1 M electricity sale	$1.1 M electricity sale
Total Land Requirements	2.7 acres	2.7 acres
Chemicals	150 gpd - Caustic (6 trucks/year at 10,000 gal trucks)	50 gpd - Caustic (2 trucks/year at 10,000 gal trucks)

Alternative 5 – Pyrolysis

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Alternative 5 – Pyrolysis

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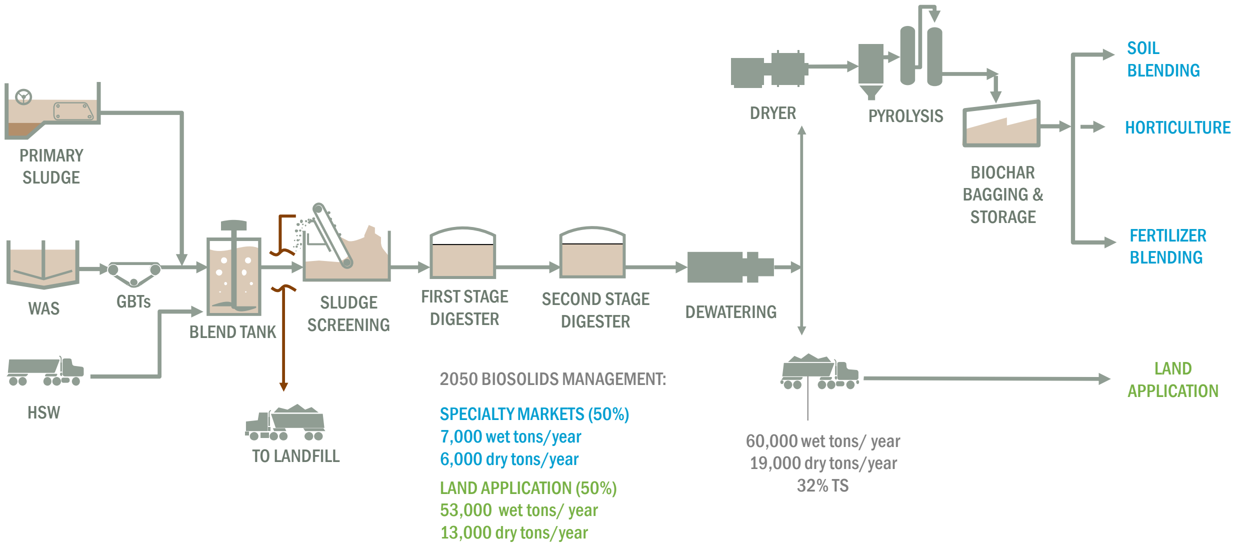
Alternative 5 – Post-Digestion, 50% Pyrolysis



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Alternative 5- Pyrolysis Key Considerations

- Emerging technology with limited application for biosolids processing
- Operational costs assume:
  - Syngas produced in the process is used with pyrolysis system
  - Natural gas only needed during startup
- Reduces total solids and volume of biosolids to be managed
- Modular design allows for easy phasing
- Opens specialty markets for biochar
  - Additional outreach is needed to develop a reliable market

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Alternative 5 – Pyrolysis

Item	Alt 5
Biosolids Storage Type	Biochar is bagged and stored in warehouse
Biosolids Storage Land Requirements	< 0.1 acre
End Use In 2050	6,700 wet tons/year – Specialty markets 53,000 wet tons/year – Land application
Number of Biosolids Trucks In 2050	9 trucks/day
Revenue	$1.1M - electricity sale $0.05M – biochar sale to specialty markets
Land Requirements	1.2 acres

Summary Economic Scoring

Biosolids Alternatives - Economic Results

Item	Alt 0 Status Quo	Alt 1 THP	Alt 2 Merchant	Alt 3 Thermal Drying	Alt 4A Lystek	Alt 4B Lystek, Winter Only	Alt 5 Pyrolysis
Biosolids Production* Wet tons/year	79,000	62,000	79,000	20,000	127,000	95,000	44,000
Capital Cost ($ millions)	$40	$660	$44	$290	$790	$790	$340
Operating Costs* ($ millions)	$5.7	$10.2	$9.5	$4.8	$10.5	$6.3	$5.1
Revenue* ($ millions) Biosolids Product	--	--	--	($0.1)	--	--	($0.04)
Biogas Utilization	($1.1)	($1.0)	($1.1)	($0.7)	($0.9)	($0.8)	($0.8)

*Operating costs, revenues and biosolids production are presented for Year 1.
All values are rounded.

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Biosolids Alternatives - Economic Results

Item	Alt 0 Status Quo	Alt 1 THP	Alt 2 Merchant	Alt 3 Thermal Drying	Alt 4A Lystek	Alt 4B Lystek, Winter Only	Alt 5 Pyrolysis
Biosolids Production* Wet tons/year	79,000	62,000	79,000	20,000	127,000	95,000	44,000
Capital Cost ($ millions)	$40	$660	$44	$290	$790	$790	$340
Operating Costs* ($ millions)	$5.7	$10.2	$9.5	$4.8	$10.5	$6.3	$5.1
Revenue* ($ millions) Biosolids Product	--	--	--	($0.1)	--	--	($0.04)
Biogas Utilization	($1.1)	($1.0)	($1.1)	($0.7)	($0.9)	($0.8)	($0.8)

*Operating costs, revenues and biosolids production are presented for Year 1.
All values are rounded.

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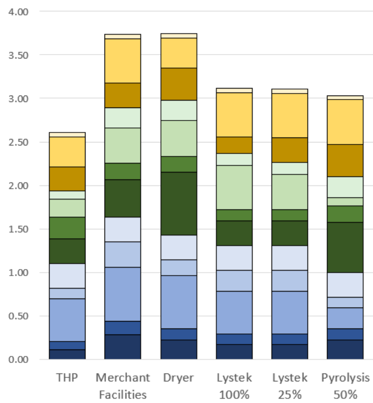
Biosolids Alternatives - Economic Results

	Alt 0 Status Quo	Alt 1 THP	Alt 2 Merchant	Alt 3 Thermal Drying	Alt 4A Lystek	Alt 4B Lystek Winter Only	Alt 5 Pyrolysis
Wet tons/year	78,500	61,800	78,500	19,800	127,400	94,600	44,200
NPV ($ millions)	$260	$1,010	$410	$450	$1,140	$980	$480
Biosolids Management Cost ($/wet tons) *	$100	$700	$100	$300	$700	$600	$300

Notes:
Biosolids production and management costs are presented for Year 1.
* Biosolids management costs include capital costs amortized over 30 years plus operating costs and revenues divided by the annual wet tons per year of biosolids produced.

Summary of Non-Economic Scoring

Biosolids Alternatives - Non-Economic Results



Alternative	Key Considerations
Alt 1 – THP	• High temperature and pressure operating system • Established technology • Limited new markets for beneficial use
Alt 2 – Merchant	• Dependent on facility for regulatory compliance and marketing end product
Alt 3 – Thermal Dryer	• Risk of fire with pellet storage • Established technology • Opens new markets for beneficial use
Alt 4A and 4B – Lystek	• High temperature and high chemical use • Established technology • Limited new markets for beneficial use
Alt 5 - Pyrolysis	• Unknown risks with system operation • Emerging technology with biosolids • Opens new markets for beneficial use

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Conclusions

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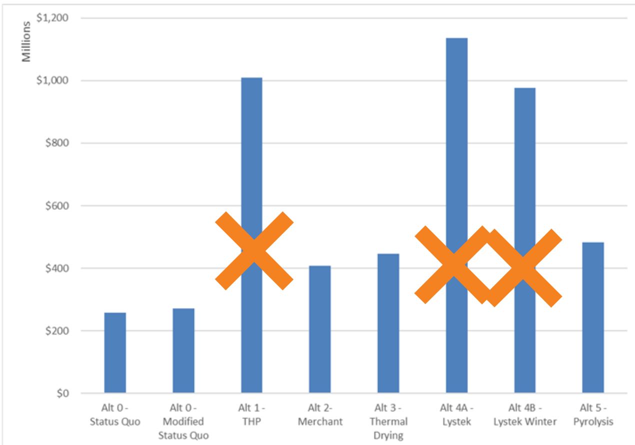
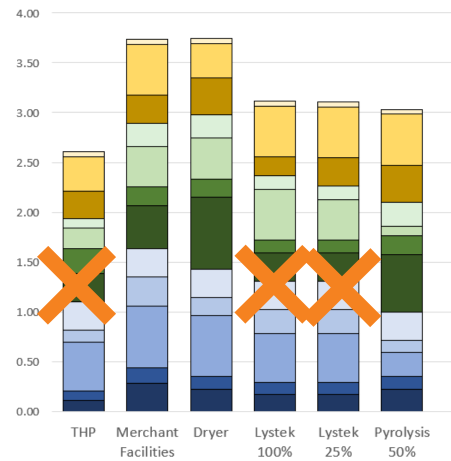
Summary of Alternatives

Net Present Value



Non-Economic Scoring



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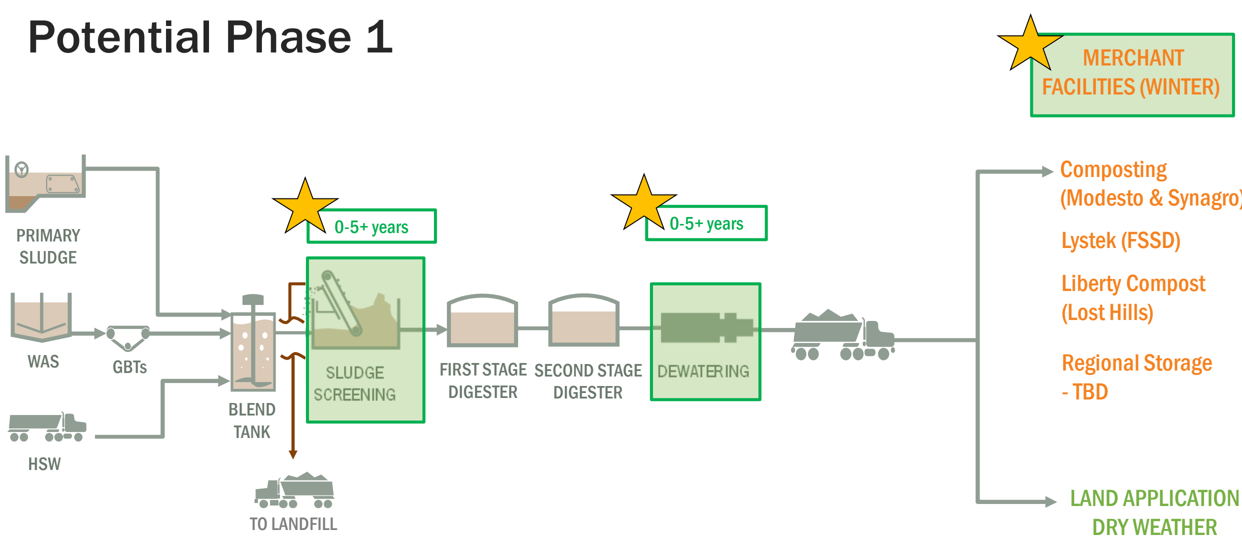
Potential Phase 1



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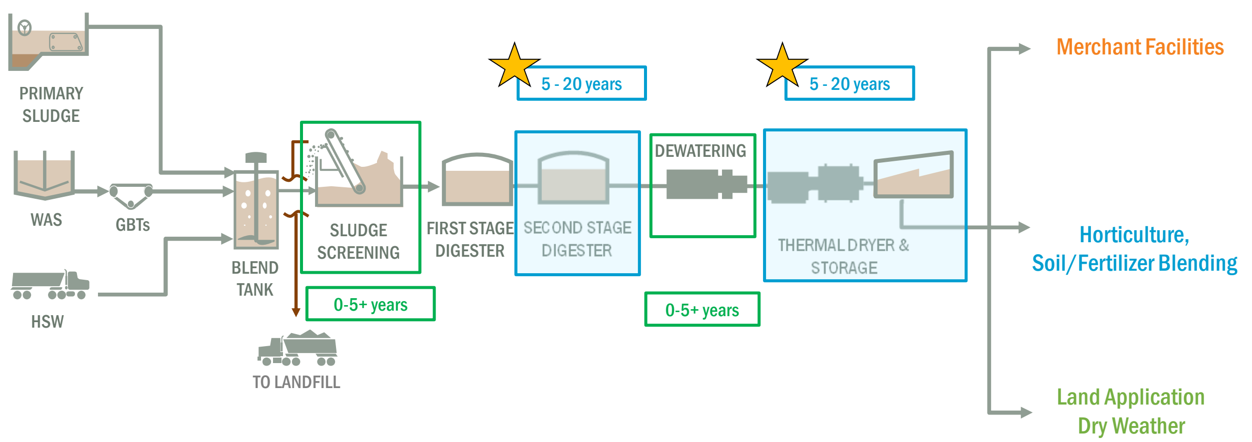
Potential Phase 2



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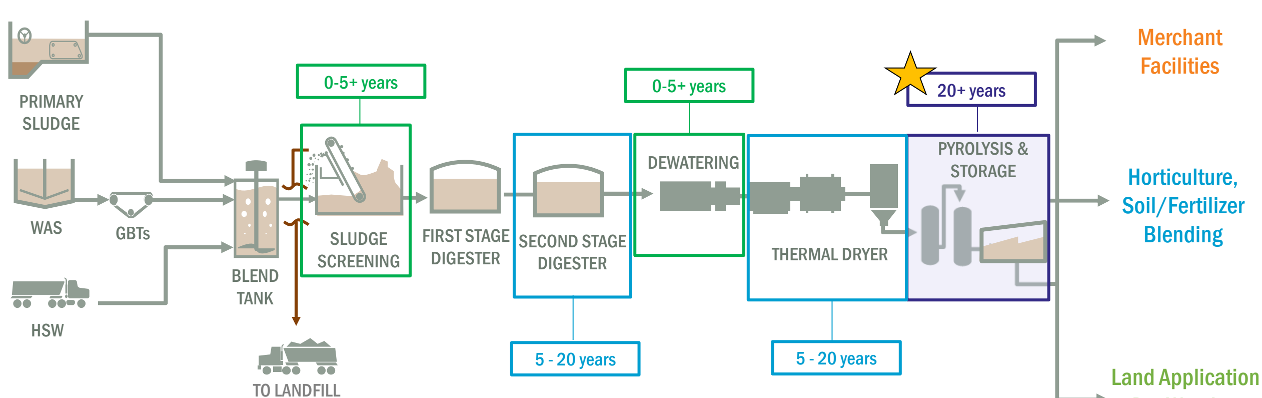
Potential Phase 3



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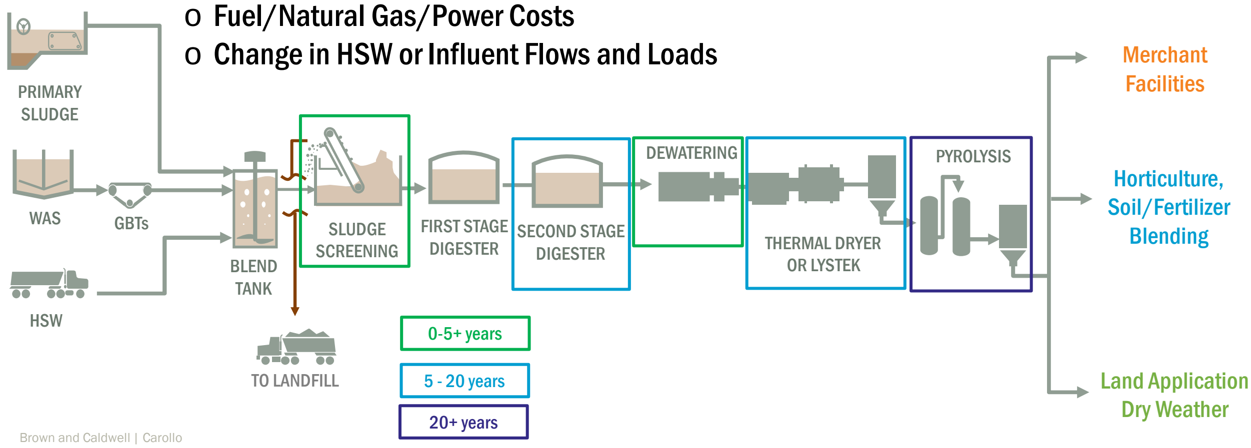
Next Steps - Confirm Phasing, Timing and Triggers

- Tip Fees – Land Application/Merchant Facilities
- Value of Biosolids Products
- New Regulations
- Fuel/Natural Gas/Power Costs
- Change in HSW or Influent Flows and Loads



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Thank you.
Questions?

Brown AND Caldwell

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Meeting Summary

Prepared for: East Bay Municipal Utility District (EBMUD)
Project Title: Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan
Project No.: 153728

Purpose of Meeting: Biosolids Alternatives Workshop 2 — **Date:** April 30, 2020
Meeting Location: MWWTP, 2020 Wake Ave — **Time:** 1 PM – 3:00 PM
Minutes Prepared by: James Hake (EBMUD), Mallika Ramanathan, Brown and Caldwell (BC), Tracy Chouinard (BC)

Attendees:

Jose Barge, EBMUD
Maura Bonnarens, EBMUD
John Corriea, EBMUD
Alicia Chakrabarti, EBMUD
Tracy Chouinard, BC
Kevin Dickison, EBMUD
Brian Dunstan, EBMUD
Cheryl Franklin, EBMUD
Erica Gardner, EBMUD
Michael Grace, EBMUD
Donald Gray (Gabb), EBMUD
James Hake, EBMUD
John Hake, EBMUD
Matthew Hoeft, EBMUD
Doug Higashi, EBMUD
Kevin Jim, EBMUD
Jennifer Ku, EBMUD
Kingsley Kuang, EBMUD
John Kyser, EBMUD
Diana Lee, EBMUD
Gary Lin, EBMUD
Rebecca Overacre, EBMUD
Mallika Ramanathan, BC
Katy Rogers, Carollo
Natalie Sierra, BC
Gary Warren, EBMUD
Darryl Yee, EBMUD
Kristine Yung, EBMUD

Draft Meeting Summary

The following provides a summary of the discussion and information that was presented during the workshop. Meeting materials are provided as an attachment.

<u>Action Items are underlined</u> and **decisions are bolded.**

<u>Overview of Alternatives</u>

1. The flow diagrams present the wet tons/yr and dry tons/year for 2050 flows and loads.
2. <u>Alternative 1: Pre-Digestion (Thermal Hydrolysis [THP])</u>
    a. Cambi is the manufacturer/vendor name. This is the process that SFPUC Southeast Plant is designing now and construction will begin soon.
    b. Benefits:

i. THP includes a pre-dewatering step upstream of digestion. The dewatered solids are conditioned in high pressure, high temperature reactor to lyse cells and increase volatile solids destruction. The pre-dewatering step reduces digester volume.
ii. EBMUD already has high volatile solids destruction; with Cambi there would be some increase however less significant than at other plants. Under 2050 conditions, with Cambi, the District would only need 6 digesters (5 duty, 1 standby). Mallika pointed out that when we were initially considering this option, the Capacity Assessment was not yet complete so it was unknown if new digesters would be needed in the future. Because the digester capacity identified that no new digesters are needed through 2050, this alternative only offers the benefit of avoided costs of future seismic upgrades of the second stage digesters.
iii. Matt noted that the Phase 3 Digester project includes seismic upgrades to the second stage digesters, but some repairs will be delayed. The repairs are adding additional post-tension bars to the second-stage digesters to meet seismic design criteria at the full liquid level.

c. Cheryl asked, can the second-stage digesters be re-purposed for winter storage? Yes, you would still need some additional volume, but this could save capital costs.
d. The market assessment identified that a THP cake does not open additional markets for beneficial use. There was limited interest from soil blenders in accepting a THP cake. The THP process produces a Class A cake but would still rely on land application as the beneficial use. For winter months, storage will be needed.
e. Maura asked, if SFPUC is going forward with this, what is their long-term plan? Natalie noted that they will continue to rely on land application but are trying to develop soil blending outlets. SFPUC's big driver was space constraints, and they have a lower VSR relative to EBMUD.
f. John Hake asked, "Has THP been used with co-digestion? I'm wondering if there's a real benefit for some easy to degrade high-strength wastes." In Europe, yes. In the US, to get class A biosolids, you must run HSW through Cambi (or separately batch heat it for pasteurization), so then it ends up being more expensive for co-digestion. Some people do WAS-only THP if they want better digestion and dewaterability. Since our VSR is already high, Cambi doesn't make as much sense.
g. Joe Barge asked, would a thickening building still be required, or could the WAS be sent straight to blend tanks and thickened using the pre dewatering? WAS thickening would still be needed to improve the pre-dewatering step. Some agencies have considered only thickening WAS and letting primary sludge thicken in the primary sedimentation tanks. This is an option or co-thickening could be considered. Because the WAS has a lower solids content, thickening would be needed.

3. Alternative 2: Merchant Facilities
   a. This alternative limits construction of new facilities onsite and relies on additional processing off-site. This alternative considers sending dewatered cake to facilities like Synagro's composting facility and the Lystek facility.
   b. The flow diagram includes sludge screening before first-stage digesters, but the screens could also be between the first and second stages. As the District determines the preferred location for screening, this flow diagram will be modified.

   c. There are existing merchant facilities that biosolids could be sent to today (shown in flow diagram). The City of Modesto has a composting facility that can accept biosolids (approximately 25,000 wet tons per year). The City of Modesto would require EBMUD to take the same volume back (e.g., 25,000 tons per year of compost) and EBMUD would be responsible for distributing the compost. The Lystek facility in Fairfield has capacity as of now and the Lost Hills Compost facility has capacity. Lost Hills is far (approximately 200 miles one way).
   d. There are talks of new facilities but nothing concrete yet. Locations, sizing and pricing are to be determined.
   e. Cheryl asked, if relying on other facilities, do we open ourselves up to future exponential costs for other companies to continue to take our product? Yes.
   f. New facilities coming online would likely be 1.5-2 times as expensive as current costs.
4. <u>Alternative 3: Post-Digestion Thermal Drying</u>
   a. Key benefits of this alternative include:
      i. Volume reduction (difference between dry and wet tons is very small) so it reduces truck hauling
      ii. The pellets open new beneficial use markets so there is more flexibility with biosolids management
      iii. Small footprint for the facility and storage of pellets
5. <u>Alternative 4A: Post-Digestion 100% Lystek</u>
   a. Lystek process prefers a lower solids content cake as feed (16 percent solids are preferred). More water is hauled offsite with the solids so Lystek will return less centrate (lower nutrients to the mainstream process).
   b. A key benefit of Lystek is that it can extend the land application season, so winter storage is reduced by approximately 1 month.
   c. Lystek still relies on land application as the primary beneficial use so winter storage is still needed (volume for 3 months instead of 4 months). Lystek is trying to branch into new beneficial use markets, but there are no firm commitments or interest, so the alternative relies on land application at this time.
6. <u>Alternative 4B: Post-Digestion, Lystek Winter Operation Only</u>
   a. This is a sub-alternative where it considers just operating Lystek in the wintertime when land application is not available. The Lystek process is easy to turn on and off.
   b. Tonnage reported is the weighted average over course of year, i.e. 16% when producing Lystek and ~22% the rest of the year.
   c. Cheryl asked, during the winter months, would we need to increase the labor in the solids area due to the addition of chemical use? For Alternative 4A, 5 new FTEs were assumed and for Alternative 4B 2.5 new FTEs were assumed.
7. <u>Alternative 5: Post-Digestion Pyrolysis</u>
   a. Pyrolysis produces "syngas" that can be used within pyrolysis system itself to offset natural gas or energy demands.
   b. John Hake asked, "Pyrolysis requires outside energy source? It's not self-sustaining with syngas?" It needs natural gas on startup and then uses syngas which makes it self-sustaining.
   c. Cheryl asked if the vendors will put this in writing. The vendors put this in writing in the proposals, but it is uncertain if they would guarantee this in a contract. Matt commented

that there aren't many facilities doing pyrolysis, so we can't fact check this. SVCW has been operating for about 1 year. SVCW has the Bioforce Tech system and Bioforce Tech has been operating the system. SVCW will be taking over operation so additional details may become available in the next year and will provide some information on energy use and operational issues.

  d. This alternative will require a new air permit, which could be challenging.
  e. Pyrolysis will reduce volume, so wintertime storage volume is small. This alternative assumes that during the summer, biosolids cake are still land applied and 25 percent of biosolids are routed to the pyrolysis system. During the winter, all biosolids go to the pyrolysis system. This results in an average solids concentration of about 32 percent for the year.

8. Capital Costs
   a. Diana asked for clarification on the bar graph. The Modified Alternative 0 assumes that 70 percent of biosolids are land applied and 30% are routed to the merchant facilities (no ADC). Alternative 2 assumes all biosolids go to merchant facilities.
   b. Rebecca asked, Does Alternative 3 (thermal drying) include storage? Yes, but the volume is small. The vendor proposals included silos for storage, and we were unable to break the cost out, but it is a small fraction of the total capital cost.
   c. Cheryl expressed concern that recent capital projects have gone over-budget, even when taking into account contingencies. Mallika pointed out that this is an apples-to-apples comparison, so underestimating capital costs would affect all the projects in the same way. This analysis focuses on the delta between the alternatives.
9. Operating Costs
   a. Analysis assumed 3 percent per year inflation over 30 years for everything except biosolids management costs
   b. Biosolids management costs
      i. Land application
         1. There is enough acreage in the Bay Area for land application. The challenge is not being able to land apply during winter.
         2. Projected costs are likely to increase with CPI. There is an assumed increase in land application for the next EBMUD contract (in 2021); after this renewal the costs were assumed to increase with CPI.
      ii. Landfill ADC
         1. Landfill ADC costs were assumed to increase sharply (30% increase every 5 years) through 2028. At that time, it is assumed that landfill ADC costs would stabilize and increase with CPI.
         2. Landfill ADC is not a reliable long-term option and in the future it may be that biosolids would only be accepted and put into the landfill (not beneficially used at the landfill). The costs reflect what could be the cost either for ADC (beneficial use at the landfill) or for landfill disposal. Both options are not reliable long-term solutions and will put the District at risk for having a reliable winter-time outlet.
         3. All alternatives (except for Status Quo) assume that landfill ADC is not used in the future.

iii. Merchant facilities will take ~5 years to build new facilities. A 6 percent increase in merchant facilities was assumed through 2025. After 2025, prices were assumed to increase with CPI. The merchant facility pricing is expected to stabilize because as more merchant facilities come online (supply increases) prices will stabilize.

10. Non-Economic Results
    a. Facility safety
        i. Facility safety took into account chemical use (similar to nutrient alternatives). The biosolids alternatives also considered other risks associated with operating systems at high temperature/high pressure (e.g., Cambi, pyrolysis and Lystek). Thermal drying also has a fire risk associated with storage of the pellets.
        ii. Fire Risk with Thermal Drying
            1. Upstream chemical usage can increase fire risk
                a. Facilities that practice CEPT with ferric (e.g. Honolulu and Encina) have higher risk.
            2. Silo/Storage of Pellets
                a. In the silo, moisture and oxygen are present. Biological activity can increase temperature and if undetected can lead to a "thermal runaway event" which can quickly turn to fire. Safety controls on other installations include thermocouples at multiple locations along the silo and nitrogen blankets (fire suppressant). If the temperature increases rapidly, most facilities try to dissipate the heat by releasing the pellets from the silo to cool. Released pellets may need to go to landfill or other emergency outlet but extra cost is better than risk of fire.
            3. Cheryl asked if thermal drying will be run by operations or PGS operators. This has not been determined and will need to be considered if thermal drying moves forward and is built.
        iii. Pyrolysis
            1. SVCW's pyrolysis systems has a biodryer upstream of the pyrolysis unit. The biodryer operates at a lower temperature than thermal dryers, and the dried product moves straight into pyrolysis unit without storage. The final biochar product is very stable with low fire risk.
        iv. Diana commented, "Alt 2 and 3 seem to have significant differences in safety but rated only 1 point apart. Adequate range to account for differences?" Mallika said that we could modify this. The initial thought was that with proper instrumentation and controls, the fire risk of pellet storage could be managed so a large difference wasn't needed. The team did look some sensitivities to see if the outcome would change at all. <u>Action Item – modify facility safety score for thermal drying (Alternative 3) to reduce the score and increase the score for Alternative 2 (Merchant Facilities), which has little to no changes in facility safety from current conditions.</u>
        v. Greenhouse Gas (GHG) emissions were reviewed and the scoring was discussed. The GHG emissions include Scope 2 and Scope 3 emissions and the BEAM

model was used to calculate emissions and offsets. The offsets for all the alternatives include land application (i.e., carbon sequestration and fertilizer offsets). Tracy Chouinard commented that there is some research suggesting that biochar (pyrolysis product) has higher carbon sequestration offset value. However, this is not yet been fully studied or accepted so biochar was assigned the same land application/carbon sequestration value as the other alternatives.

11. Site Plans
    a. Thermal Drying
        i. Dryer building is usually 3 levels, which could accommodate new dewatering equipment. However, we need to address dewatering issues before we'd build a thermal dryer, so we wouldn't be able to make use of this added benefit.
        ii. Mallika noted that the costs do not include the third level for dewatering. The dewatering facility could be built first, with space left for a thermal dryer building to be located adjacent to dewatering.
12. Conclusions
    a. Cambi has the lowest non-economic score and highest NPV. Therefore, it is recommended that this alternative not be carried forward.
    b. Lystek similarly has NPV and lower non-economic score. Thermal drying and pyrolysis have lower NPVs and higher non-economic scores. Merchant facilities (Alternative 2) also has high non-economic score and low NPV. A potential phasing plan was reviewed with merchant facilities, thermal drying and pyrolysis.
    c. John Hake noted that the thermal dryer could use biogas that is not used in the cogeneration system. Mallika agreed. One variation that the team looked at was what happens as natural gas costs increase? This together with the value of power generation may drive using biogas in the thermal dryer. Action Item – consider for future using biogas for the thermal dryer.
    d. Alicia asked, are we eliminating alternatives prior to matching them with liquid stream alternatives? Mallika highlighted that the process model did integrate the liquid and solid streams and considered dewatering return streams. The solids alternatives were developed assuming the HPO system continues with secondary treatment, which provides a conservative assumption for WAS production. The team did consider and quantify the nutrient reduction that could be recognized with Lystek (due to less centrate return to the mainstream plant). The result is about 5% reduction in nutrient loading to the secondary system. Thermal drying will increase nutrient return by approximately 5% due to condensate return. Cambi (Alternative 1) also increases ammonia and dissolved organic nitrogen (nonbiodegradable fraction).
    e. Gary Lin asked, "Are we assuming that all alternatives will require a new dewatering building? If so, does it make more sense for the Group that sludge screening be put upstream of dewatering so they can be in the same building, same odor control system, etc?" Kevin Dickison commented that screening before digesters in pilot study wasn't very beneficial. Putting screens before dewatering would be to improve biosolids quality.

13. Master Plan Timeline
    a. Matt to schedule a meeting with the Steering Committee with the following goals:
        i. Eliminate alternatives definitively
        ii. Select a liquid and biosolids alternative for 2050
        iii. Develop plan to get from 2020 to 2050
    b. After Steering Committee meeting, have another workshop.

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APPENDIX B – BIOSOLIDS TECHNOLOGY OVERVIEW

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The following section provides details of the technologies that were considered during the screening process. The technologies are organized based on status (embryonic, emerging, established).

Embryonic Technologies

Gasification

Gasification is an oxygen-starved or limited air thermal process that generates an energy-dense gas (pyrogas or syngas). It operates at temperatures of 500 - 1,300 degrees °C, which provides additional solids destruction. Pyrogas or syngas are a combustible gas with a lower heating value between 100 and 300 Btu per standard cubic foot. Pyrogas can likely be used in a combustion engine but requires upstream conditioning and engine modification for the low energy content of the fuel.

Historically, gasification has worked well with dry feedstocks such as wood and plastics but has not been successful at full scale with higher moisture feedstocks, including biosolids. A biosolids only facility that was installed at full scale by MaxWest Environmental in Sanford, Florida, ceased operations because MaxWest Environmental filed for bankruptcy. However, the MaxWest Environmental gasification technology has since been licensed to Aries Clean Energy. Aries Clean Energy operates gasification facilities that receive biosolids and other, drier feedstocks at installations in Lebanon and Covington, Tennessee, using a different gasification technology. The facility in Lebanon treats approximately 1,100 tons per year of feedstock; biosolids is a small percentage of the feedstock. Aries Clean Energy has also installed twelve other gasifiers in industrial and commercial settings using wood waste as the primary feedstock, with a different gasification configuration than the MaxWest technology. Thus, the experience of gasification with biosolids-only feedstock is minimal and the experience with a biosolids mixed feedstock remains variable.

Emerging Technologies

Pyrolysis

Pyrolysis is the thermal decomposition of organic matter under anaerobic conditions. The volatile fraction of the organics is converted to a gas (pyrogas or syngas). Pyrogas or syngas can be condensed and converted to liquid fuel or the gas can be utilized to heat the pyrolysis reactor. In some configurations, the inert solids fraction forms an end-product called biochar which can be used as a soil amendment and carbon sequestration product. Biochar is viewed as have environmental benefits because the product has lower contaminants, such as contaminants of emerging concern, compared with traditional biosolids. There is active research that indicates that biochar may have promise as an adsorbent, similar to activated carbon.

Pyrolysis has been demonstrated at full-scale at multiple facilities using other feedstocks (e.g. wood waste and municipal solid waste). Silicon Valley Clean Water (SVCW) installed a pyrolysis facility that began operation in 2017. The facility processes 7,000 wet tons per year (at 25% solids) using equipment installed by BioForce Tech. BioForce Tech is currently operating the facility and marketing the biochar product; the facility operations will be turned over in the upcoming year to SVCW for operation and BioForce Tech will continue to market the biochar product. It should be noted that air permitting for the pilot system took a considerable amount of time that will need to be factored into any implementation schedule of pilot or full-scale facility. The facility, as shown in Figure B-1, consists of a drying step upstream of the pyrolysis reactor. The BioForce Tech system can utilize a biodryer or a standard thermal dryer. The biodryer has a larger footprint and lower energy requirement. At SVCW, the first generation biodryer units have been replaced with newer models, and operating data are limited.

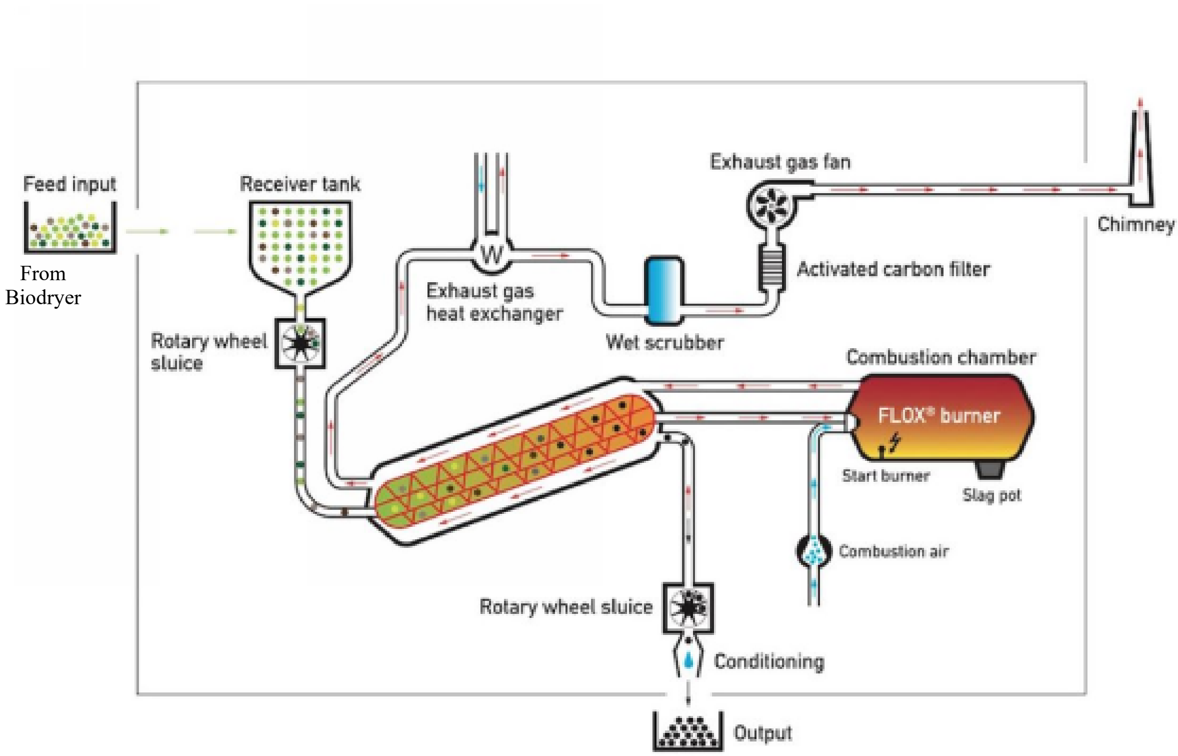

Figure B-1. Schematic of the BioForce Tech Pyrolysis Process

All pyrolysis systems have a drying step prior to the pyrolysis unit. A biodryer operates by air flow passing through the biosolids to help aerate the biosolids. This allows for accelerated biological degradation, as in composting. This aerated drying step is of 48-56 hours, during which time the material is aerated at different speeds to facilitate oxygenated degradation, bringing the temperature of the biosolids up to about 150 °F within a few hours. The heat helps dry the biosolids, and in this stage, the airflow is increased to help increase evaporation/moisture removal. The only external heat comes from recovered hot water (from the pyrolysis unit), so BioForcetech claims that the drying process is energy neutral. While a thermal dryer would require less footprint, it requires more heat than recovered from the pyrolysis unit. At least 50% of its heat would need to be supplemented by natural gas, increasing cost and GHG emissions.

Greenhouse-Style Solar Drying

Solar drying itself is not an emerging technology. Solar drying relies on sunlight to dry biosolids and the practice has been used for decades. Solar drying beds are a land intensive practice which typically does not have application in an urban setting. Greenhouse style solar dryers can reduce footprint and contain odors and dust; several are in operation in California.

In order to reduce footprint, solar drying can also be implemented by using a greenhouse style enclosure with heated floors. This type of solar drying system utilizes a solar thermal collector system, which consists of parabolic mirrored solar troughs and drives. The solar thermal collector tracks the sun and concentrates sunlight onto the thermally efficient receiver tubes in the trough focal line. In these tubes, a thermal transfer fluid is circulated, pumped through a series of heat exchangers and is converted into thermal energy that is used to heat the floors of the facility and increase efficiency of the solar drying process. Figure B-2 illustrates a picture of a solar thermal collector system.

Figure B-2. Solar Thermal Collector System Utilized in the Greenhouse-Style Solar Drying System

The concept of pairing solar collectors with a heated floor has been successfully demonstrated in Surprise, Arizona. At this installation, solar collectors are used to heat water to 350 degrees F for use as the thermal transfer fluid. Based on the field data from the Arizona project, the solar collector system needs to create approximately 4.3 million British Thermal Units per hour (MMBTUh) to dry 27 tons of biosolids per day. Supplemental heat can be used if there is not enough solar radiation.

Solar dried biosolids tend to be lower quality relative to drum dryers. Unlike many of the other technologies considered herein, solar drying as a process is not considered to yield Class A biosolids under 40 CFR 503 except through extended pathogen testing. The dried product is usually very dusty and irregular in shape, which limits end-use markets.

Established Technologies

Class A Anaerobic Digestion

Three anaerobic digestion technologies were identified as pathways for production of a Class A biosolids cake:

- Thermophilic digestion with batch processing
- Temperature Phased Anaerobic Digestion
- High-Solids Anaerobic Digestion

Generally speaking, these Class A digestion processes require holding the sludge at a temperature greater than or equal to 55 C for a specified length of time, usually 24 hours. Different digestion configurations can achieve this treatment goal. The City of Los Angeles has produced Class A biosolids using batched thermophilic digestion, which results in 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. Alternatively, under this option, the District could pursue pathogen equivalency testing for an alternate thermophilic configuration.

TPAD consists of digesting solids in two distinct temperature phases, arranged in series. True TPAD configuration does require a cooling step between the first and second stage. To produce Class A biosolids, TPAD can be configured to provide batch holding so that sludge is held for 24 hours at thermophilic temperatures. Typically this step is performed with batch holding tanks located downstream of the thermophilic digester and upstream of the cooling process for the mesophilic second stage.

High-solids digestion can be achieved by increasing the solids concentration of the digester feed (i.e., 5% to 8%); this is often achieved by co-thickening digester feedstocks. A robust mixing system is needed to provide adequate mixing in the digester. Feeding at a higher rate increases the hydraulic capacity of existing digesters and reduces heating demands. To achieve Class A product the digester temperature must be in the thermophilic range. High-solids digestion can also be achieved with recuperative thickening, where digester contents are continuously thickened to increase the solids concentration in the digester. A key disadvantage to this option is that it increases energy requirements associated with heating the digester contents; heat is lost during the recuperative thickening process.

Thermal Hydrolysis (THP)

THP is pre-digestion process that utilizes high temperature and high pressure to lyse bacteria cells and promote the release and solubilization of particulate organic matter. THP significantly increases the rate of digestion, allowing a reduced digester residence time for achieving the same VSR and gas production. In addition to the impact on digestion kinetics, THP also increases the extent of VSR and gas production by about 10% to 20%. More importantly, THP dramatically decreases the viscosity of the digester feed sludge, allowing the feed solids concentration to be in the range of 9% to 12% rather than a conventional range of 4% to 6% total solids (TS). This combined with the improvement in digestion rate, THP allows the volumetric solids loading rate to the digestion process to be increased and the SRT decreased, increasing the solids handling capacity of a given digester volume.

In certain configurations, THP produces a Class A biosolids cake. The THP digestate tends to have improved dewaterability and less odors. The dewatering centrate from a THP digestate will have higher ammonia and recalcitrant dissolved organic nitrogen (rDON) loads than with a conventional digestion process. A 5% to 20% increase has been observed at THP facilities for ammonia, dependent on observed VSR increase. There is a 1 mg/L increase in rDON observed in THP facilities.

THP, as marketed by the vendor Cambi, is an established technology in Europe with full-scale facilities in service since 1995; the first installation in the US (DC Water, Blue Plains AWT) has been operating since late 2014 and since then more systems have been constructed, while others are currently in the planning, design, and construction phases. THP uses medium-pressure steam to create the high temperature and pressure conditions. Figure B-3 provides a schematic of the Cambi^{TM} THP process, which is the assumed configuration for planning purposes.

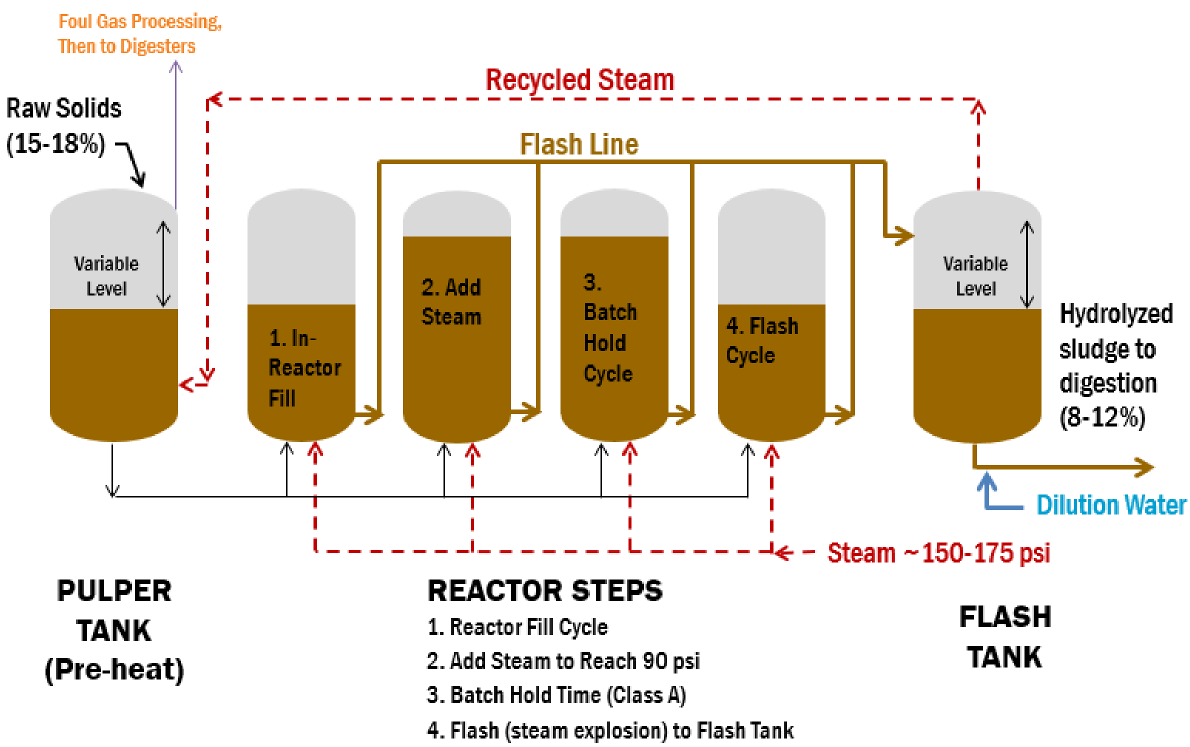

Figure B-3. Cambi™ Thermal Hydrolysis Process

While THP systems can reduce digester volume required, it does require ancillary systems and buildings that can impact total system cost, complexity, and footprint. Ancillary equipment includes steam boilers, pre-dewatering centrifuges, raw cake storage, and sludge cooling systems. The market assessment concluded that a THP cake could be used in soil blending operations; however, there is uncertainty as to how much THP cake could be marketed to such operations and how much interest there really is. Thus, it is expected that the primary end-use of a THP cake would be land application during dry weather months.

Thermal Drying

There are two main types of thermal dryers: direct and indirect dryers. The indirect systems utilize a heat medium (e.g., oil or other liquid) that is used to heat and dry the biosolids. The biosolids and heated air do not come in direct contact with each other. Conversely, with a direct dryer, biosolids and heated air come into direct contact. Thermal drying typically produces a Class A dried pellet that has a 95% solids concentration; thus the volume of product is significantly reduced. Both types of thermal dryers are established technologies, but direct drum dryers have been used in the largest applications. For example, one of the larger systems, the Massachusetts Water Resources Authority (MWRA)'s facility in Quincy, Massachusetts, has been in operation since the early 1990s processing roughly 300 tons per day. The Milwaukee Metropolitan Sewerage District has produced dried product under the commercial name Milorganite® for over 75 years. Their current system consists of drum dryers processing up to 137 tons per day. Within California, both the Sacramento Regional Sanitation District (Regional San) and Encina Joint Powers Authority (Encina JPA) both have direct thermal dryers that process approximately 20 dry tons per day, and Irvine Ranch Water District is constructing a new thermal dryer to process approximately 10 dry tons per day. As noted in the market assessment, a thermally dried product can be used in soil and fertilizer blending operations, commercial landscape operations, golf courses and/or agricultural land application.

The thermal drying process will include return flows due to condensate form the thermal dryer system; this concentrate return stream will contain additional nitrogen loads that can be returned either to sidestream treatment or to the secondary system. The design of storage silos for thermally dried products needs proper controls, alarms and safety features to avoid the potential for combustion of the pellets. This includes features such as thermocouples for temperature monitoring in the storage silos and nitrogen blanketing systems for fire suppression. While the dried product can be sold commercially, several factors can impact this pricing, including pellet quality, seasonality, and proximity to bulk customers. While some portion of the product is sold, both Regional San and Encina JPA land apply their dried product as well.

Incineration

Of the established technologies, incineration of dewatered solids achieves the greatest reduction in volume and mass for subsequent reuse or disposal by eliminating the water content of the solids and oxidizing the organic material in the sludge. The resulting sterile ash consists of the inert portion of the dry solids. The overall reduction is greater than 90% of wet solids feed. While there are opportunities for beneficial use of the ash, it is typically sent to landfill for disposal.

Although municipal solids are combustible, they will only sustain combustion without auxiliary fuel (autogenous operation) if enough water is removed in the dewatering process. The amount of heat that can be released per unit mass of solids is called the heating value and is determined by the ratio of carbon, hydrogen and sulfur within the sludge. The sludge's heating value and combustion air temperature determine if autogenous operation can occur; if the combustion temperature is not high enough for a given sludge's heating value, auxiliary fuel is required to sustain combustion. A heat and mass balance is performed for all post-dewatering incineration options given the sludge's heating value, especially where volatile solids reduction occurs through anaerobic digestion. Incineration is particularly suited for plants with limited space, large solids generation, no anaerobic digestion, and continuous, controlled operation despite weather conditions. Complex and advanced air emissions control equipment is required to meet air regulations and permitting of a new incineration facility in California would likely be a long process.

Thermal-chemical hydrolysis (Lystek)

The thermal-chemical hydrolysis process (TCHP), is also referred to as Lystek, which is the sole manufacturer of the patented process. The process utilizes a combination of high-speed shearing, chemical alkali addition (typically potassium hydroxide to elevate pH to 9.5 to 10.0), and steam injection (pressure of 8 pounds per square inch to raise process temperatures to 158 to 167 degrees F). Lystek can be located upstream or downstream of anaerobic digestion, however the full-scale experience is limited to post-digestion installations. Figure B-4 provides a process schematic of Lystek in a post-digestion configuration.

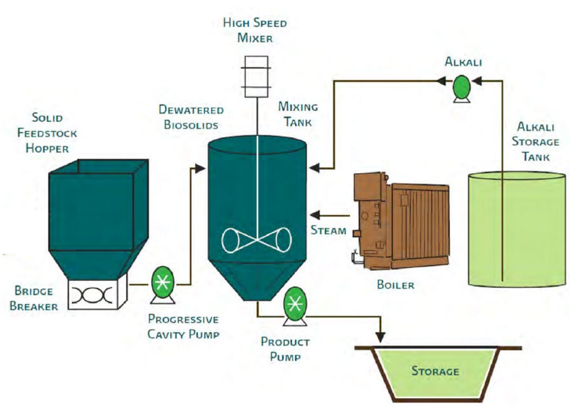

Figure B-4. Lystek Process Schematic

Source: Lystek.com

Lystek's experience has been with dewatered biosolids in the 15% to 18% TS range. Dilution water is often used if feed solids concentrations are higher. Because the process does not result in VSR, and chemicals are added, the total volume of solids leaving the facility will be greater than what is fed to the system. The end product solids concentration will be equal to the solids concentration of the feed; therefore the product volume will be greater than a traditional biosolids cake which typically has a solids concentration of 20% or greater.

The final Lystek process meets EPA Class A requirements and can be marketed by Lystek as a liquid fertilizer referred to as Lystegro. The consistency of the end product is different than a typical biosolids cake. The product is a pumpable slurry and typically tanker trucks are used for distribution to land application sites where the product is injected as a soil amendment. Lystek is currently working with neighboring Bay Area counties (e.g., Solano, Sonoma, etc.) to allow for extended land application seasons with the Lystegro product based upon its registration as a fertilizer. As noted in the market assessment, the primary end-use for a Lystek product is land application in dry weather months.

Lystek has a number of Canadian installations but entered the US market in 2016 with the 150,000-ton Organic Material Recovery Center located in the Fairfield-Suisun Sewer District in California. This complex serves as a regional biosolids processing facility, receiving biosolids from other plants in the area.

Composting

Composting uses controlled biological processes to degrade the organic material in biosolids, generating heat to raise temperatures in the compost pile to the pasteurization range. Biosolids composting has been successfully performed in the U.S. since the late 1970s. Biosolids composting involves blending dewatered biosolids with carbonaceous bulking agents (e.g., food waste and/or yard waste), which help increase the porosity of the compost mixture and provide the proper carbon to nitrogen ratio. Typical California-based operations utilize aerated static-pile composting. The composting process transforms Class B biosolids into a Class A product provided that pile temperatures meet the Class A requirements in the EPA Part 503 rule (131 degrees F for at least 3 days).

Composting systems require a large area for the facility, amendment, and finished product curing and storage. During the composting process, the composting mass roughly reduces 40% to 50% in weight and volume. However, because a bulking agent is added as a carbon source, the end product volume is typically larger than the original starting volume of biosolids. The finished product cannot be used in certified organic production and would not likely be used in the production of many fresh produce crops. While a biosolids compost product does have value in horticultural and agricultural markets, the supply of compost has grown and will likely continue to grow in future years. With SB1383, food and green waste streams have and may continue to be diverted to composting operations; the product from these operations is certified organic and limits the marketability and value of a biosolids-derived compost.

Drying Beds

Drying beds are a common type of sludge air drying. They typically consist of concrete sidewalls with a porous media composed of sand and gravel or another media to allow liquid to drain. Having porous media is less critical when drying dewatered cake. Drying beds operate in a batch process with laying the dewatered biosolids within designated areas for at least 12 days to allow the cake to dry. When the material reaches at least 75% TS, it may be possible to verify that the biosolids have achieved Class A (e.g. through pathogen testing). To obtain Class A, the time for each batch may significantly increase. In addition, drying beds require a significant footprint. They are similar to solar drying, described above, but drying beds are not enclosed, which can also result in odors. Drying beds are not typically used in urban and large systems where odors can be an issue and land is limited.

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APPENDIX C – SCREENING BIOSOLIDS TECHNOLOGIES AND WORKSHOP MATERIALS AND MINUTES

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Biosolids Management Alternatives Screening

Brown and Caldwell

1

Biosolids Screening Criteria

Screening Criteria	Description (Pass/Fail)
Ability to Meet Regulations	Complies with near term biosolids regulations, supports beneficial use, and can be adapted to meet anticipated regulations.
Technology Maturity & Risk (at this size)	Proposed technology/approach has at least one installation with a capacity of 20 mgd (~14dtpd) or greater, with at least one year of successful operation (within the last 10 years) at 90% capacity. Established: Pass Emerging: Pass/Fail Embryonic: Pass/Fail
Ease of Permitting	Technology has been permitted at a WWTP
Site Constraints	Structures, equipment, etc., fit within the existing MWWTP boundaries
Independent Operations	Facilities can be fully operated by EBMUD staff (i.e., contract operations by independent entities is not required).

2

Biosolids Screening Criteria

Screening Criteria	Description (Pass/Fail)
Ability to Meet Regulations	Complies with near term water, air, and land related regulations, and can be adapted to meet anticipated regulations.
Technology Maturity & Risk (at this size)	Proposed technology/approach has at least one installation with a capacity of 20 mgd (~14dtpd) or greater, with at least one year of successful operation (within the last 10 years) at 90% capacity. Established: Pass Emerging: Pass/Fail Embryonic: Pass/Fail
Ease of Permitting	Technology has been permitted at a WWTP
Site Constraints	Structures, equipment, etc., fit within the existing MWWTP boundaries
Independent Operations	Facilities can be fully operated by EBMUD staff (i.e., contract operations by independent entities is not required).
End Use Diversification	Provides new end use markets beyond status quo (Class B land application and landfill ADC)

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Current Status of SB 1383 Implementing Regulations

State-wide Targets for Diversion of Organics from Landfills:

-- 50% by 2020

-- 75% by 2025

Local Jurisdictions

-- **Must** adopt ordinances / policies that in aggregate will result in meeting the state-wide goals

-- Jurisdictions must begin reporting in 2022

-- Jurisdictions must begin enforcement by 2024

Landfilling

-- Revised draft implementing regs DO NOT ban landfill disposal of biosolids

-- Baseline for starting measuring diversion is 2014

4

4

Biosolids Management Alternatives

Pre-Digestion

Anaerobic Digestion

Post Digestion

Summary of Assumptions

- Projected biosolids loads for 2050, without R2
  - Assumed increase is linear with population projection
  - Approximately 80,000 wet tons/year (= 220 wtpd and approximately 55 dtpd)
- Regulatory Endpoint
  - Provide the ability to beneficially use biosolids
  - Identify a path to produce a Class A product

Alternative 0
Status Quo - Class B Cake

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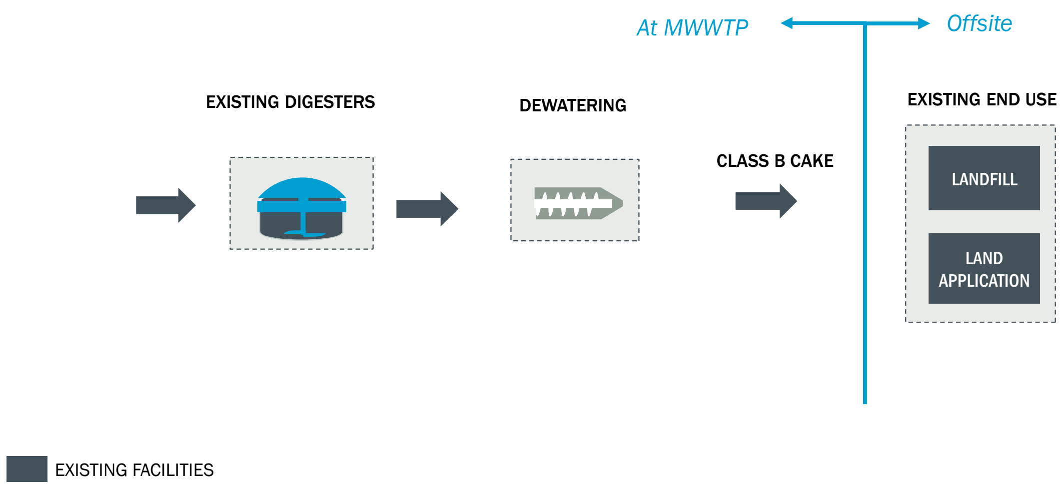
Alternative 0 – Status Quo



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Current Biosolids Practices

- District produces Class B biosolids
  - Average 200 wet tons per day = 50 dry tons per day
  - Average 8 tractor-trailers per day
- Two handling contracts:

Dry Weather Season

- Denali Water
- $34/ton
- Land application

Wet Weather Season

- Synagro
- $63/ton
- Land application, compost, landfill ADC

9

Distribution in 2018 and 2019

End Use Unit Cost	Landfill ADC $63/wet ton	Land Application $34/wet ton	Compost $63/wet ton	Lystek at FSSD $89/wet ton
2018	7,100 wet tons 10%	55,000 wet tons 77%	9,100 wet tons 13%	--
2019	22,000 wet tons 34%	40,000 wet tons 64%	1,200 wet tons 2%	200 wet tons <1%
$ M/year if 100% diversion to end use	$4.6M	$2.5M	$4.6M	$6.6M

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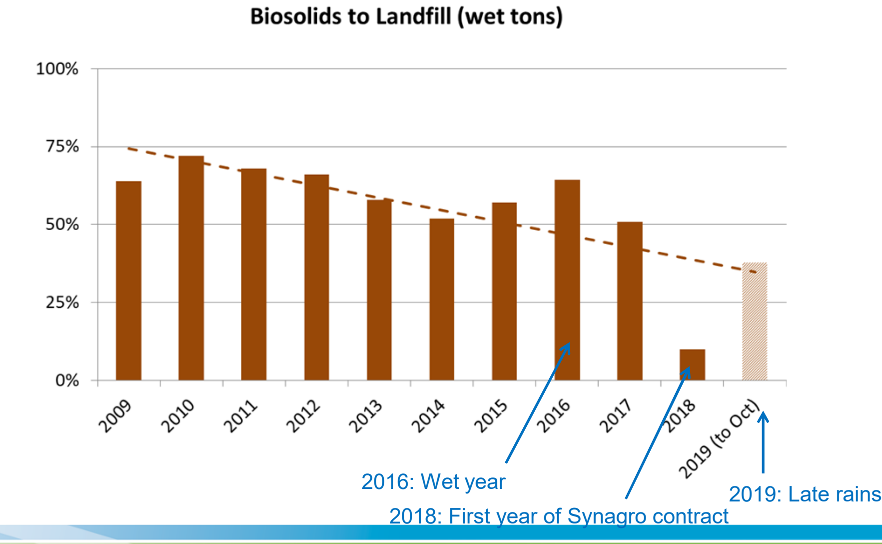
Landfill Dependence Reduced



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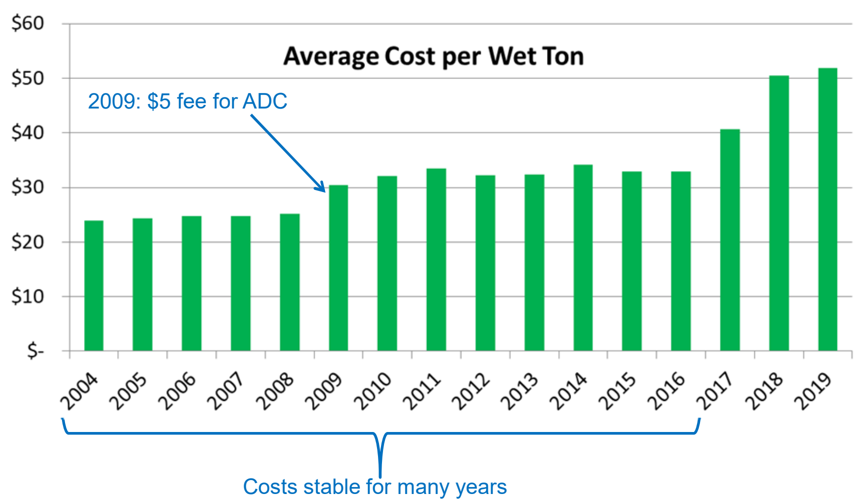
Average Biosolids Management Costs are Increasing



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Alternative 0A
Modified Status Quo - Class A Cake

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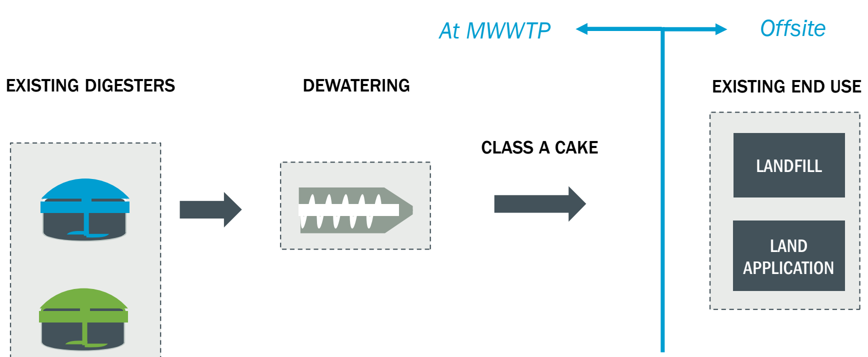
Alternative 0A – Modified Status Quo



NEW DIGESTERS/ PROCESS MODIFICATIONS

- Temperature Phased Anaerobic Digestion
- Thermophilic Batch (PFRP Process)
- High Solids Digestion

EXISTING
NEW

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Alternative 0A Screening Results

Technology/ Configuration	Description	Pass/ Fail	Screening Notes	Considerations
Temperature Phased Anaerobic Digestion	Thermophilic, batch tanks, mesophilic	Pass?	Does not provide new end use options.	Requires additional tankage
Thermophilic Batch Digestion	Thermophilic, batch process	Pass?	Does not provide new end use options.	Requires additional tankage?
High Solids (5-8%) Anaerobic Digestion	Digesters operate at high solids concentration	Pass?	Does not provide new end use options.	Increases capacity

- Assumes existing digesters are utilized
- Thickening improvements to increase solids feed concentration or recuperative thickening (e.g., Anaergia Omnivore)
- "Dry" digesters not considered

Thermophilic Anaerobic Digestion

0.2 acres

- New Batch Tanks
- Allowance for heat exchangers, pumps and piping
- Existing digesters configured to thermophilic and mesophilic

Alternative 1
Class A Cake, Pre-Digestion at EBMUD Property

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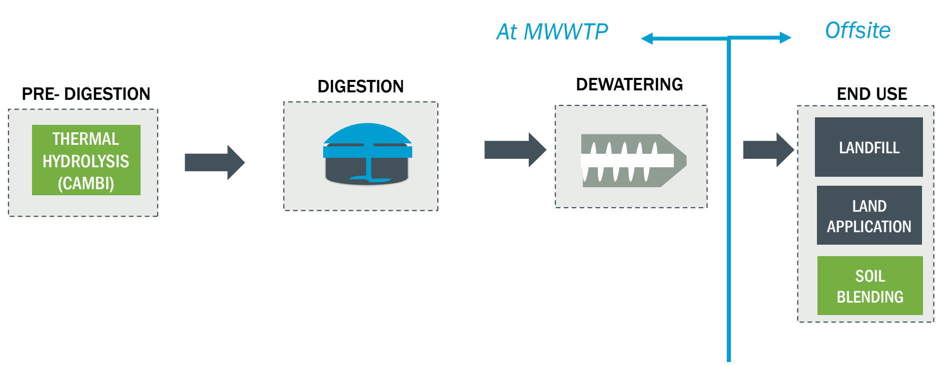
Alternative 1: Class A Cake, Pre-digestion



EXISTING
NEW

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Alternative 1 Screening Results

Technology/ Configuration	Pass/ Fail	Screening Notes	Considerations
Thermal Hydrolysis (THP) (i.e., Cambi)	Pass	- Footprint ~0.2 acres	- Potential for new end use markets (soil blending) - Improved final biosolids quality

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100% THP- CAMBI
0.2 ac

- Pre-dewatering
- Thermal hydrolysis
- Odor control
- Utilizes existing digesters

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Alternative 2
Class B Cake
Haul 100% to Merchant Facility

Brown AND Caldwell

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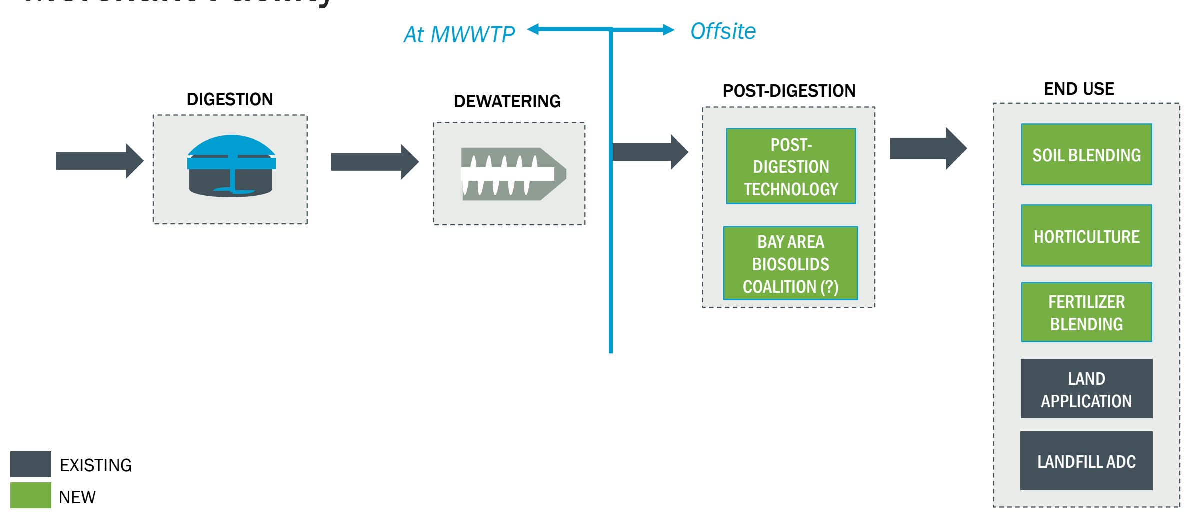
Alternative 2 – Class B Digestion, Haul 100% Offsite to Merchant Facility



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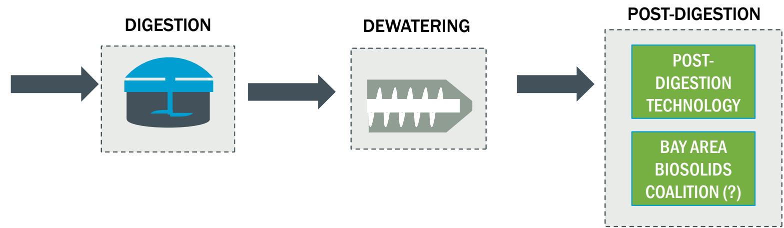
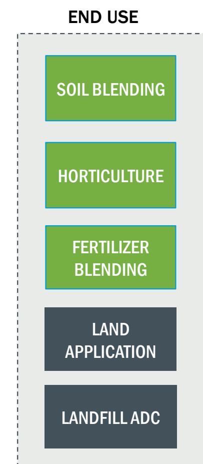
Alternative 2 – Class B Digestion, Haul 100% Offsite to Merchant Facility





Potential Merchant Facilities

- Denali Compost Facility (Altamont) - $70-$90/wet ton
- Synagro Compost Facility (Peninsula/Sacramento) - $70 - $90/wet ton
- Lystek Facility (~300 wet/day capacity)- $90/wet ton
- City of Modesto (50 wet ton capacity) - $37/wet ton + hauling
- Liberty Compost (Lost Hills) – 200 + miles away

EXISTING
NEW

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Alternative 2 Screening Results

Technology/ Configuration	Pass/ Fail	Screening Notes	Considerations
Merchant Facility (technology TBD) Bay Area Biosolids Coalition Facility - ?	Pass	- Location outside of MWWTP property	- Potential for new end use markets - Long-term contract provides certainty in long-term management costs - No capital investment or land requirements

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Alternative 3:
Class A Product, 100% Post-Digestion Technology at EBMUD Property

Alternative 4:
Class A Product, 50% Post-Digestion Technology at EBMUD Property

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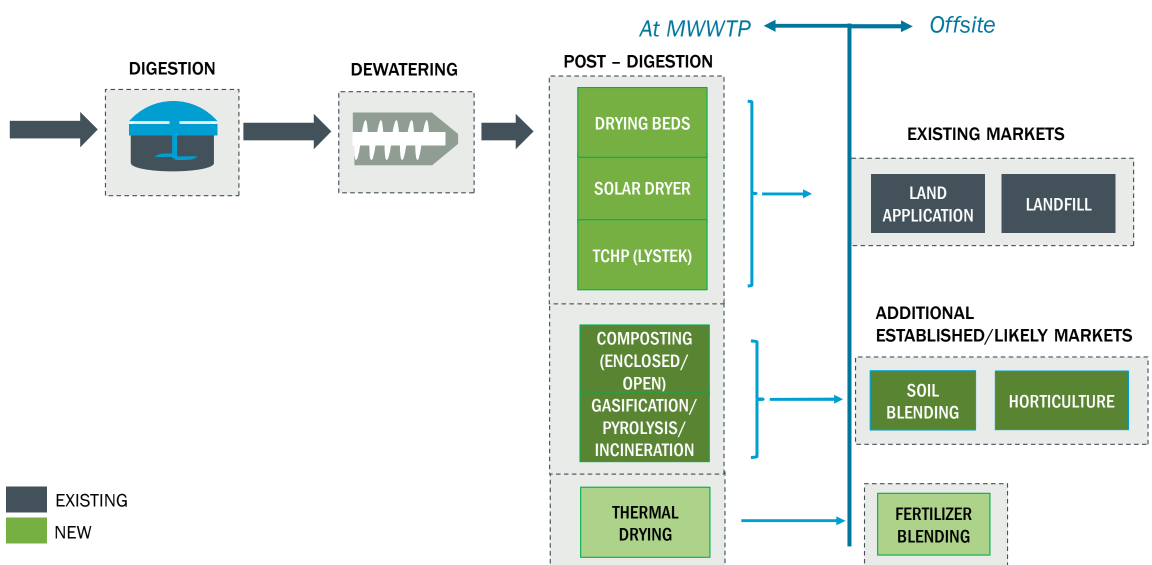
Alternative 3: Class A Product, 100% Post-Digestion



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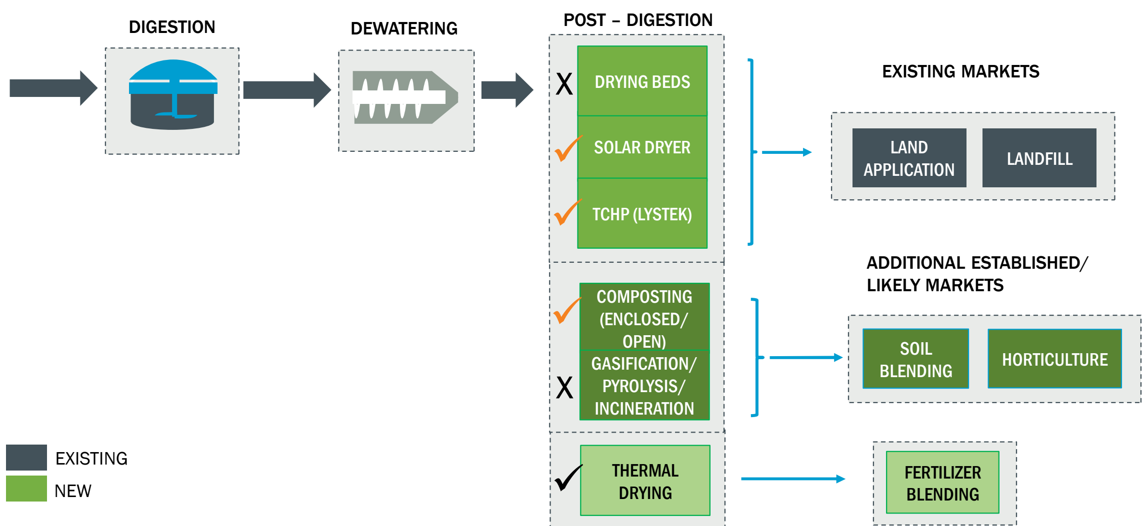
Alternative 3: Class A Product, 100% Post-Digestion



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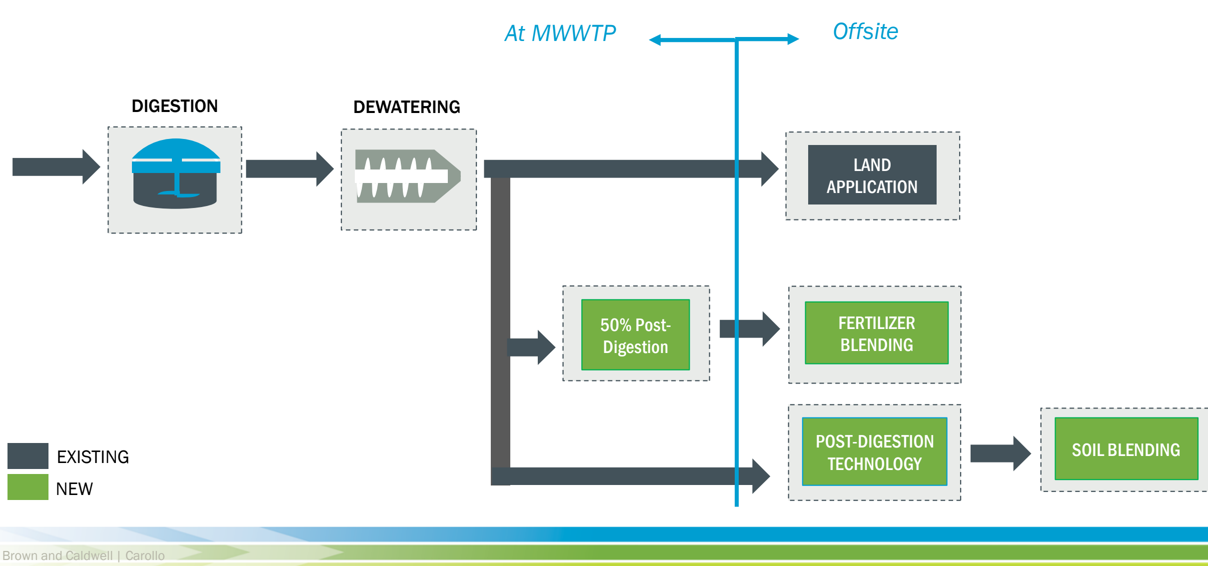
Alternative 4: Class A Product, 50% Post-Digestion



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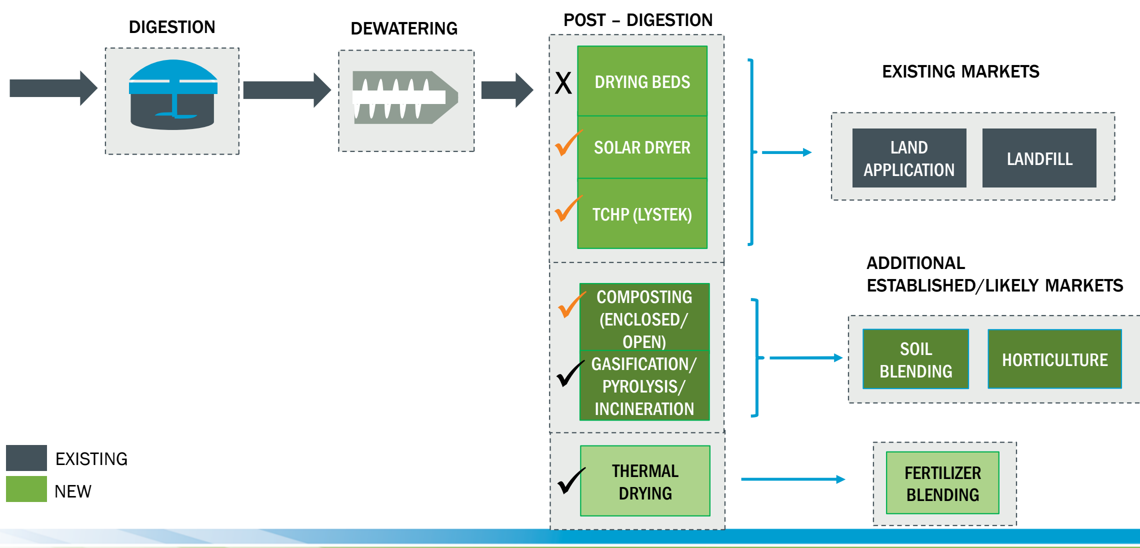
Alternative 4: Class A Product, 50% Post-Digestion



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Alternative 3 and 4 Screening Results

Technology/ Configuration	Pass/ Fail	Screening Notes	Considerations
Drying Beds	Fail	Large footprint	
Solar Dryer, greenhouse style with heated floors	Fail ?	Lesser quality dried product – limited end use markets	Consider smaller facility ?
Thermo-chemical hydrolysis (Lystek)	Pass?	Does not yet provide new end use markets	Consider smaller facility ?
Open Composting	Fail	- Not permittable - Does not beneficially use the land.	
Enclosed Composting	Pass?	- Does not beneficially use the land. - The market may not support 100% of composted solids	Consider smaller facility at MWWTP or other property?

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Alternative 3 and 4 Screening Results

Technology/ Configuration	Pass/ Fail	Screening Notes	Considerations
Incineration	Fail	While incinerators can be permitted, it is a long, difficult process that can take 10+ years.	
Pyrolysis	Fail for 100% ? Pass for 50%?	Emerging Largest facility is in Redwood City, CA at 7,000 tons per year. It has been operating since 2017. Biochar can provide additional end use markets	Consider 50% at MWWTP?
Gasification	Fail	Emerging. Largest facility is in Lebanon, TN at 1,095 tons per year (the fraction of biosolids is even less). It has been operating since 2016.	
Thermal Drying	Pass	Small footprint, opens up additional end use markets	Consider 100% and 50% at MWWTP?

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100% Solar drying = 8 acres

50% Solar drying = 4 acres

- Greenhouse with heated floor
- Solar array
- Heat exchanger
- Dried product storage & offload
- Process control room
- Odor control

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100% TCHP = 0.9 acres

50% TCHP = 0.5 acres

- Enclosed facility
- Operations building
- Receiving bays
- Mixed storage tanks for receiving
- Processing area
- Odor control

33

100% Composting = 13 acres

50% Composting = 6 acres

- Composting areas
- Mixing areas
- Bulk agent storage
- Odor control for enclosed composting

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100% Pyrolysis = 0.6 acres

50% Pyrolysis = 0.3 acres

- Pyrolysis reactors
- Process control room
- Odor control

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100% Thermal Drying = 2 acres

50% Thermal Drying = 0.9 acres

- Thermal dryers
- Dried product storage & offload
- Process control room
- Odor control

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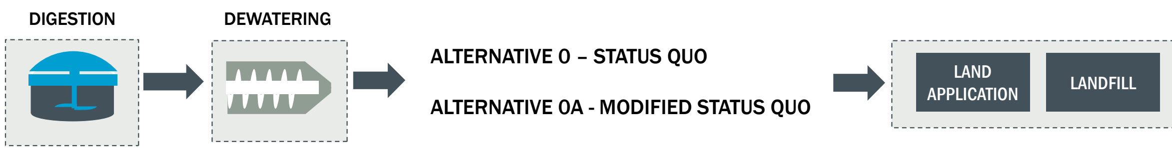
Summary of Alternatives



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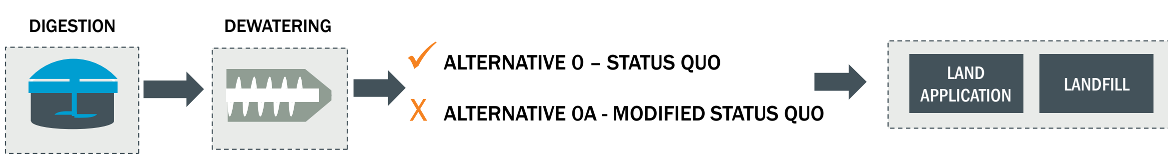
Summary of Alternatives



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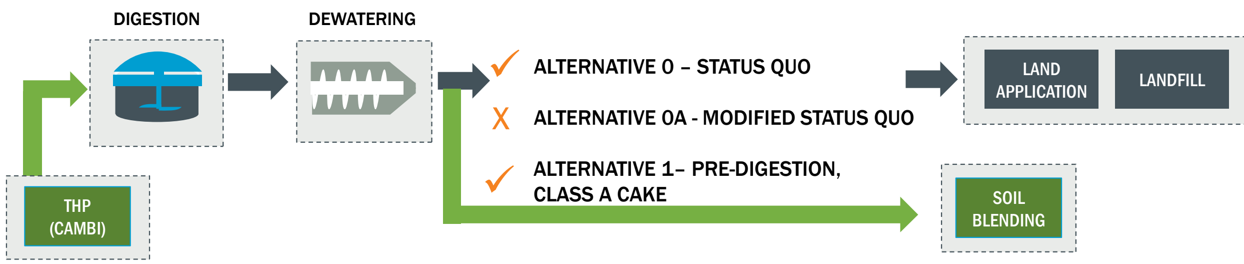
Summary of Alternatives



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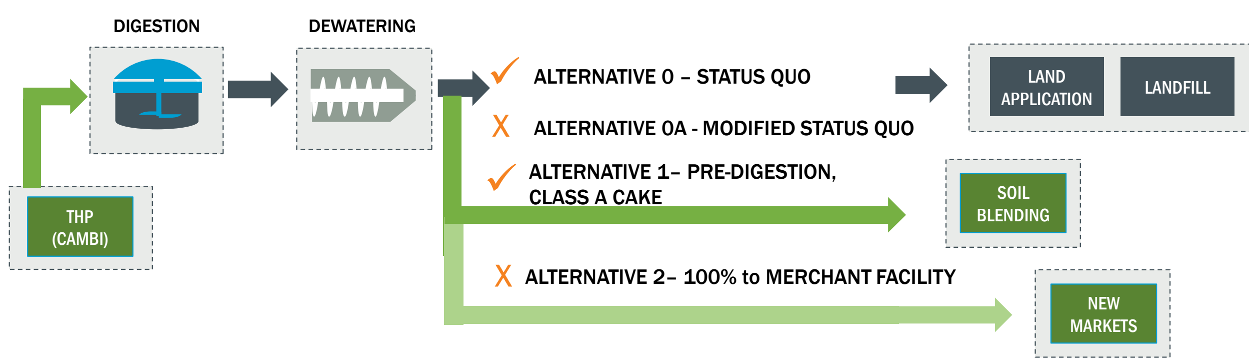
Summary of Alternatives



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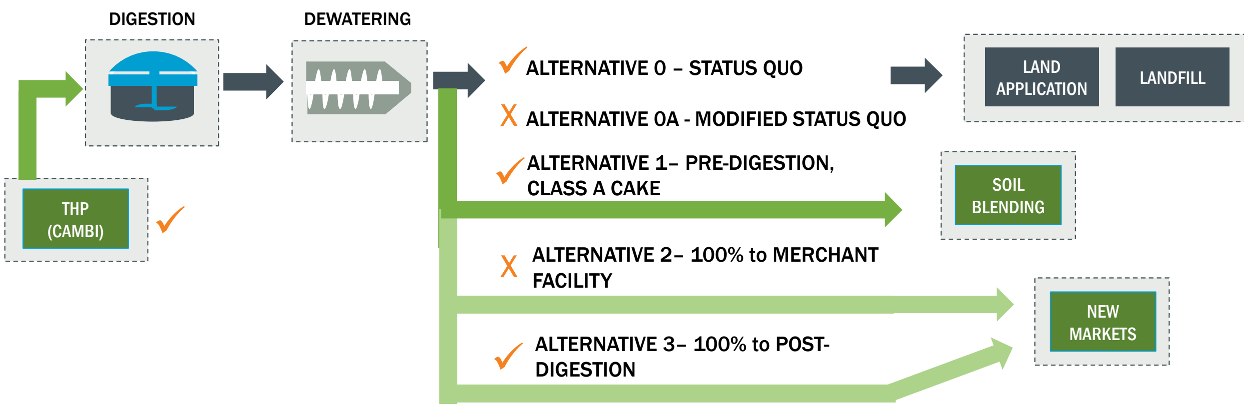
Summary of Alternatives



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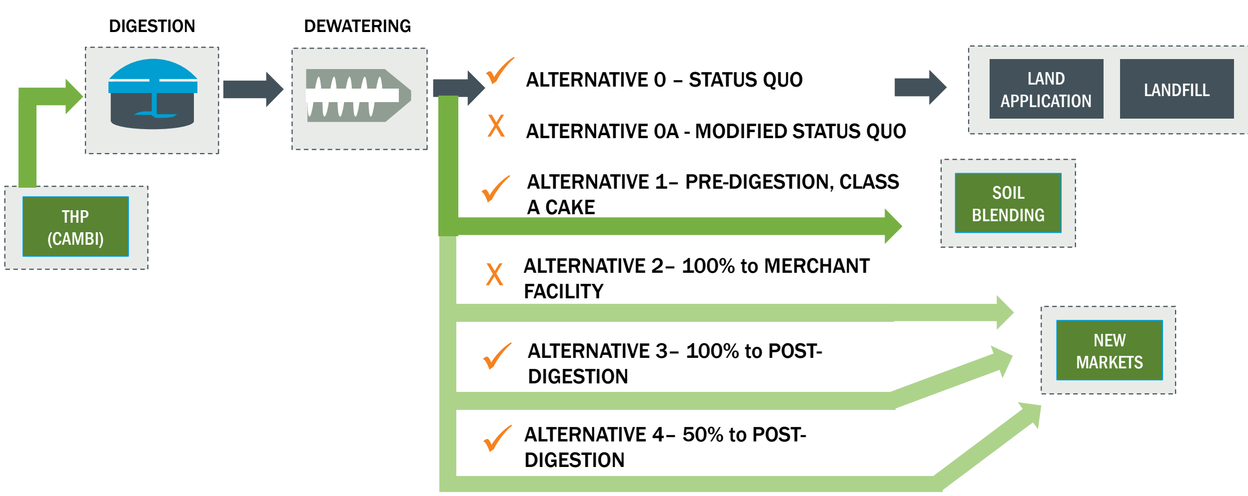
Summary of Alternatives



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Summary of Six Biosolids Management Alternatives for Further Evaluation

	Alternative	Technology/ Configuration
0	Status Quo (Class B Cake)	X
0A	Modified Status Quo (Class A Cake)	X
1	Pre-digestion, Class A Cake	THP (i.e., Cambi)
2	100% to Merchant Facility (offsite)	X
3	100% to Post-digestion, Class A Product	Lystek Thermal Drying
4	50% to Post-digestion, Class A Product (Diversified portfolio)	Pyrolysis Compost Thermal Drying

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Next Steps

- Develop the pairwise comparison evaluation framework (January workshop)
- Capacity Assessment at MWWTP
- Develop and evaluate 12 alternatives
  - Integrate solids and liquids alternatives
  - Select 4 alternatives for additional refinement

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Thank you.
Questions?

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Technologies for Alternatives 3 and 4

Technology	Description	Carry Forward	Comments
Solar Drying	Established Class A product Land application	X	
TCHP (Lystek)	Emerging Class A product Land Application	✓	100% to post-digestion
Composting	Established Class A product New end use markets	✓	50% or similar to Post-digestion
Pyrolysis	Emerging Class A Product Volume reduction New end use markets	✓	50% or similar to Post-digestion
Thermal Drying	Established Class A product Volume reduction New end use markets	✓	100% to post-digestion 50% to post-digestion

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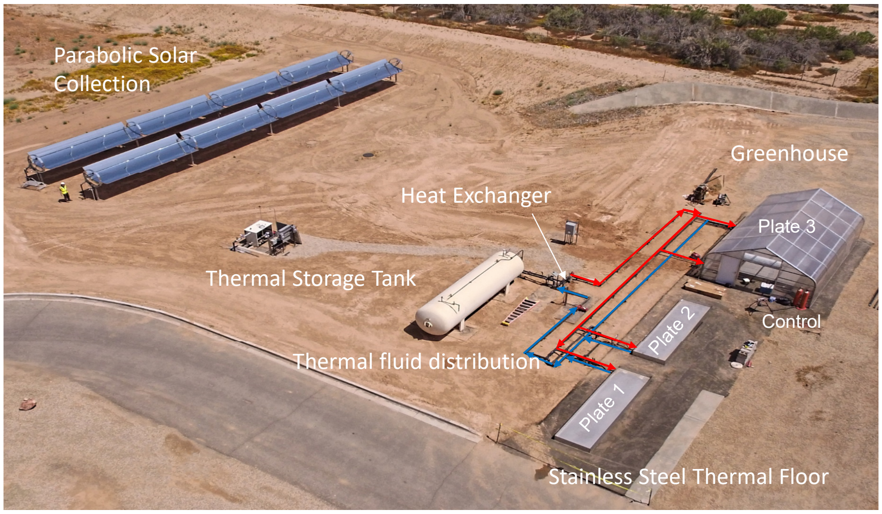
Surprise, Arizona



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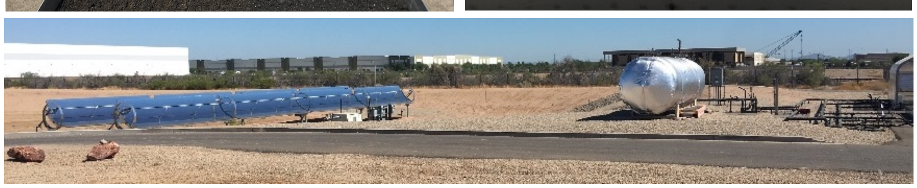
Solar Heated Thermal Floor Enhanced Greenhouse Biosolids Drying



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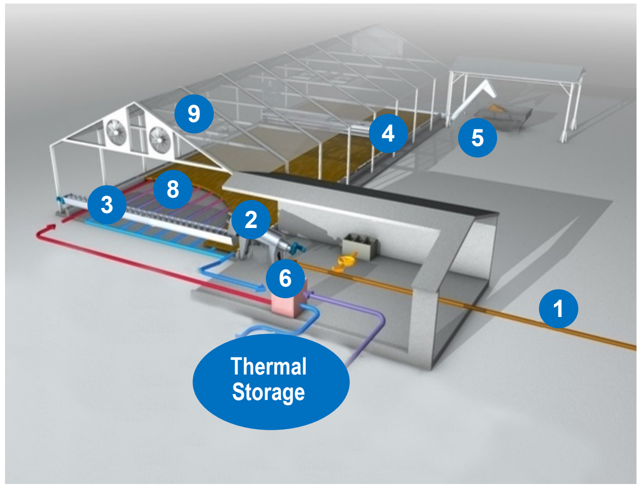
Full Scale System

1. Liquid sludge delivery
2. Dewatering
3. Solids distribution
4. Solids mixer
5. Dry solids disposal
6. Thermal storage
7. Heat exchanger
8. Stainless steel thermal floor
9. Solar greenhouse



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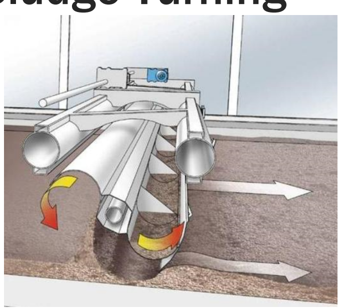
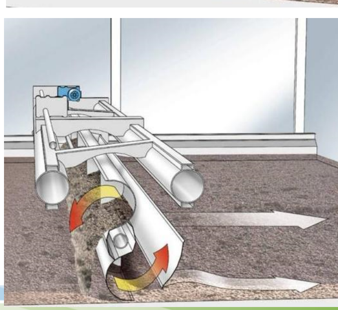
Sludge Turning





Taking the sludge in one shovel

Passing the granulation plate

Rotating over the drum

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Thermal Floor

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PFAS Health Risks - Overview

- Toxicity of PFOA & PFOS and other PFAS have uncertainties
  - Epidemiological studies and laboratory animal studies have not shown consistent and conclusive findings
  - Cancer incidence studies in NY, NH, and MN not indicative of PFAS effects
  - If PFAS is causing health effects, the effects appear to be subtle
  - Current risk-based standards/guidelines for PFOA and PFOS are protective (e.g. EPA's PHA, Health Canada's numbers)
- Reasons for concern
  - PFAS in drinking water elevates PFAS in blood
  - Little data for PFAS other than PFOA and PFOS; unknowns → caution

Slide courtesy Steve Zemba, Sanborn Head

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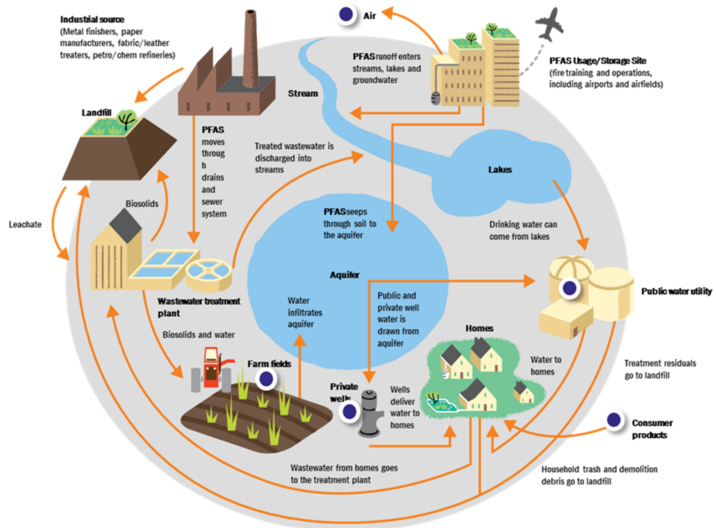
PFAS

(Polyfluoroalkyl Substances) touches the entire water cycle



Points of exposure
- Air
- Consumer Products
- Private/Public water
- Food and food wrappers

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PFAS Remediation

- Proven & Commercialized Liquid Remediation Methods
  - Activated carbon (Ex Situ)
  - Anionic exchange resins (Ex Situ)
- Proven & Commercialized Soil Remediation Methods
  - In situ modified carbon sorption
  - In situ modified minerals sorption
- Proven & Commercialized Solids Remediation Methods
  - Incineration (1,000 – 1,200C)
  - Landfill disposal

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Estimated energy requirements

	Electricity Requirements (kWh/dt)
Thermal Drying	3
THP – CAMBI	10
TCHP – Lystek	70
Solar Drying	Negligible
Pyrolysis	145

Note: All technologies have similar heat requirement, except pyrolysis.

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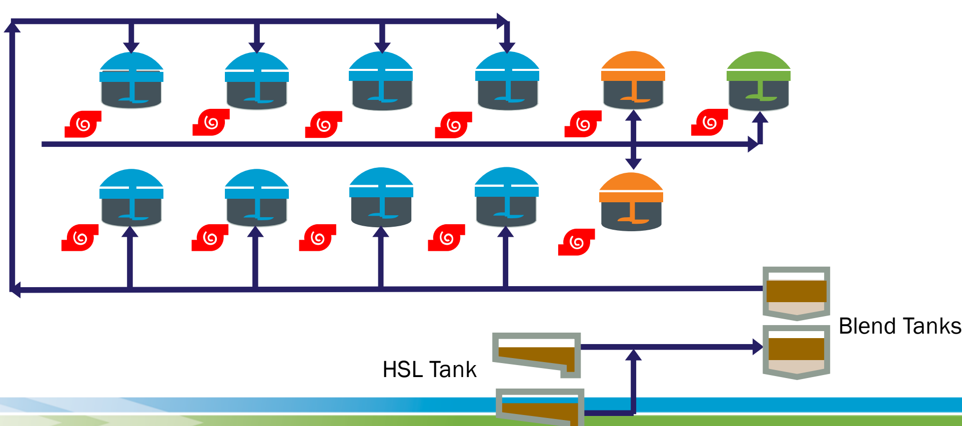
Piping improvements needed for batch thermophilic (PFRP Process)



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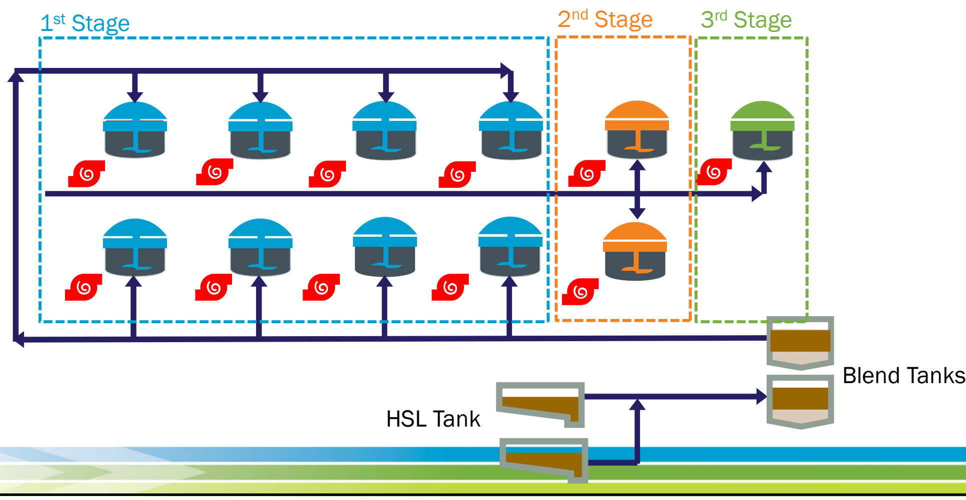
Step 1 Step 2 Step 3 Step 4

Converting to a 3-stage plug flow system



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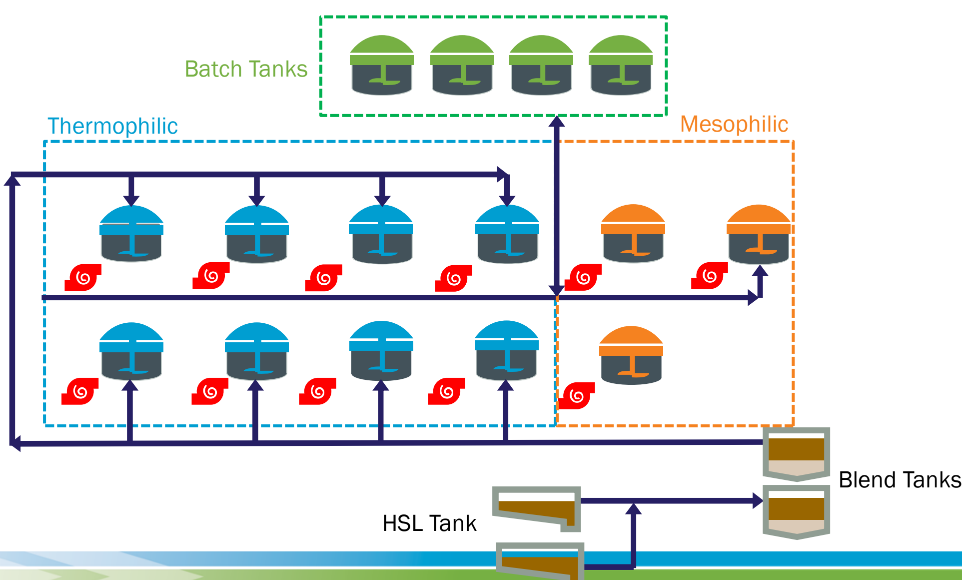
Step 1 Step 2 Step 3 Step 4

Converting to TPAD with batch tanks



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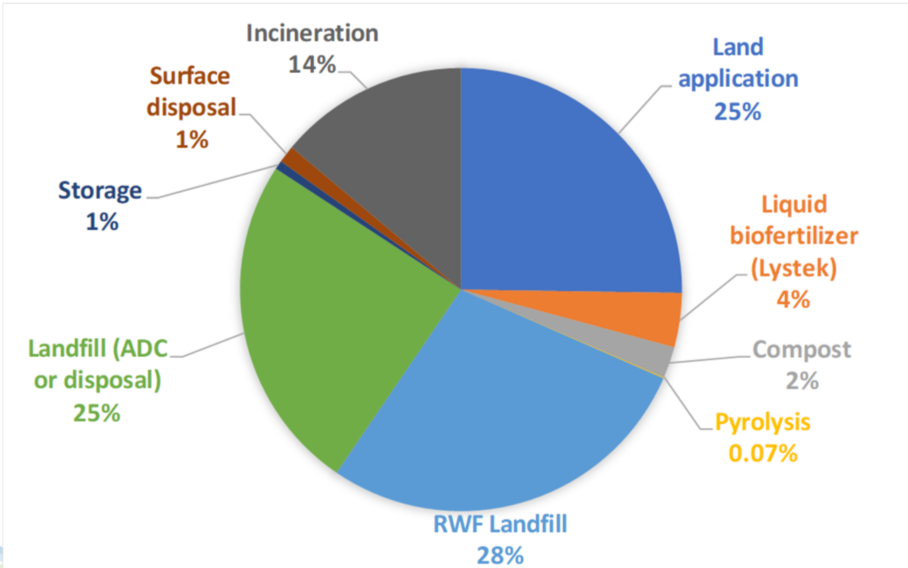
Bay Area utilities have relied heavily on landfilling

SB 1383 will tend to drive demand to other end



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Recent Market Changes

- Land Application
  - Prices and sites for dry weather land app stable: $30-$45/wet ton.
  - Sites for wet weather land application are limited, potential for expansion possible, but limited by farming practices and weather.
- Landfilling – Bay Area WWTPs competing for available capacity. Tip fees increasing 50-70% for wet season ADC or disposal under recent Bay Area contract renewals.
- Biosolids Compost – Few biosolids facilities in Northern California. Increased availability of food waste/green waste compost has intruded on traditional markets and depressed revenues statewide.
- Overall, year-round management costs are increasing as market and regulatory pressures increase

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Pyrolysis Facilities

Company	Facility	Location	Feedstock	Type	Scale	Status	Capacity (WT)/Year
Bioforcetech	Silicon Valley Clean Water	Redwood city, California	Biosolids	Pyrolysis	Full-scale	2017 (operation)	7,000
Bioforcetech	Edmonds Wastewater Treatment plant	Edmonds, Washington	Biosolids	Pyrolysis	Full-scale	2021 (design)	N/A
Anaergia	Rialto Bioenergy Facility	San Bernardino, California	Biosolids/foodwaste (70%)	Pyrolysis	Full-scale	2020 (design)	109,500
KORE Infrastructure	LACSD	San Bernardino, California	Biosolids	Pyrolysis	Full-scale	2020 (design)	7,950
KORE Infrastructure	LACSD joint Water Pollution Control Plant	Carson, California	Biosolids	Pyrolysis	Pilot/Demonstration	2008-2015 (closed)	1,000
Anaergia	Encina Wastewater Authority	Carlsbad, California	Biosolids	Pyrolysis	Pilot/Demonstration	2014 (finished)	N/A

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Gasification Facilities

Company	Facility	Location	Feedstock	Type	Scale	Status	Capacity (WT)/Year
Aries Clean Energy	Lebanon Waste to Energy Plant	Lebanon, Tennessee	Woodwaste, Biosolids (minor)	Downdraft gasifier	Full-scale	2016	1,095
Aries Clean Energy	City of Covington	Covington, Tennessee	Woodwaste, Biosolids (minor)	Downdraft gasifier	Full-scale	2014	7,300
Aries Clean Energy	Linden Roselle Sewerage Authority complex	Linden, New Jersey	Biosolids	Gasifier	Full-scale	Q4 2020 (construction)	130,000
Aries Clean Energy	Aries-Holloway Bioenergy Facility	Lost Hills, California	Agricultural Biomass	Downdraft gasifier	Full-scale	Q3 2021 (design)	60,225
Ecoremedy	Morrisville Municipal Authority	Morrisville, Pennsylvania	Biosolids	Gasifier	Pilot/Demonstration	2020 (construction)	7,300
Aries Clean Energy	Sanford Utility Department	Sanford, Florida	Biosolids	Gasifier	Full-scale	2009-2014 (failed)	14,235

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Land Application (Bulk Agriculture)

- Market is well understood
- EBMUD is currently operating a successful program ~ 70,000 wet tons/year
  - Typical haul distance is in the ~100 mile range
- Class A and B cake, Lystek, and THP (e.g., Cambi) product fall under this category
- Inexpensive option today – but may change in the future
  - Wet weather ADC is becoming less available and more expensive
  - Competition for land may make land application more expensive in the future

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Soil Blending

- Class A biosolids mixed with other soil products (sand, soil, bark, etc.) blended to meet usage requirements
- Typical Markets – landscape (garden centers, landscape yards)
- Biosolids Class A products (compost, THP cake, pellet, biochar)
- Competing with non-biosolids compost products
- Less interest in Class A (THP) biosolids by soil blenders, than in past market research

Windrowing DC Bloom to cure CAMBI biosolids before blending

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Meeting Summary

Prepared for: East Bay Municipal Utility District (EBMUD)
Project Title: Integrated Main Wastewater Treatment Plant (MWWTP) Master Plan
Project No.: 153728

Purpose of Meeting: Alternatives Screening Workshop No. 1 **Date:** Dec 19, 2019
Meeting Location: MWWTP, 2020 Wake Ave **Time:** 8:00am – 11:30 am
Minutes Prepared by: Mallika Ramanathan, Brown and Caldwell
Mary Lou Romero, Brown and Caldwell
Katy Rogers, Carollo

Attendees:

Yun Shang	Gary Warren	Ike Bell
Jeff Biehl	Maura Bonnarens	Alicia Chakrabarti
Kevin Dickinson	Brian Dunstan	Cheryl Franklin
Erika Gardner	Don Gray	James Hake
John Hake	Doug Higashi	Matt Hoeft
Michael Hyatt	Jennifer Ku	Rebecca Overacre
John Kyser	Shelly Masuda	Eileen White
Carol Weir	Darryl Yee	Kevin Jim
Mallika Ramanathan	Katy Rogers	Andre Gharagozian
Mary Lou Romero	Tracy Chouinard (via phone)	Natalie Sierra (via phone)

Draft Meeting Summary

The following provides a summary of the discussion and information that was presented during the workshop. Meeting materials are provided as an attachment.

Action Items are underlined and **decisions are bolded.**

Alternatives Screening Approach

a. An overview of the master plan work flow was reviewed. This workshop focused on the second step of the alternatives analysis, which will help identify technologies to allocate land and CIP budget. This approach will provide flexibility to accommodate future technologies and/or regulatory changes. The screening discussed in this workshop is a high-level fatal flaw analysis. Following this workshop, the alternatives evaluation workshop will include costs and sensitivity analysis of the selected placeholder technology.

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b. The universe of options previously presented were organized into 6 alternatives (6 nutrient alternatives and 6 biosolids alternatives). Operational strategies, primary sedimentation tanks, thickening and dewatering options can apply to all the alternatives, so they will be paired with the selected alternatives in the next phase of the evaluation. Under each alternative, various technologies were screened using the screening criteria to get to one technology per alternative.

Nutrients Alternatives Screening

a. The screening criteria was reviewed: Ability to meet regulations, technology maturity and risk, ease of permitting, site constraints, and independent operations. For the technology maturity criteria, an established technology was scored as "passing" in this category. An emerging and embryonic technology scored could score pass or fail in this category. Engineering judgement and consideration of pilot testing was considered when scoring pass or fail scores for these technologies.
    a. There was concern from EBMUD as to how the timing of piloting and construction of new facilities will be planned for. The master plan approach is to start with the end point in mind and work back to determine steps to get to the endpoint. As part of the master plan, the roadmap will provide timelines and triggers to indicate when facilities need to be constructed or piloted.
b. The screening assumptions were reviewed:
    a. All facilities must fit within the existing MWWTP and wet weather facility (WWF) boundaries.
    b. BACWA Level 3 Nutrient Removal, which indicated TN= 6 mg/L (year-round) and TP=0.3 mg/L (year-round)
        i. This is a conservative regulatory scenario but helps ensure that the selected alternative is a viable alternative for the long-term and minimize "no-regrets" investments in nutrient removal improvements. Regardless of the alternative ultimately selected for the Master Plan, nutrient removal improvements would be phased based on treatment needed and to maximize flexibility moving forward. Eileen pointed out that the board has expressed that Level 3 is not likely to be enforced and had concerns that this regulatory endpoint was overly conservative, possibly screening out alternatives that EBMUD is interested in. EBMUD was in agreement that it is prudent to plan for Level 3, so long as the plan was based on incremental steps and phasing that allows the District to implement facilities that are appropriate for reduced treatment standards.
        ii. The Consultant team clarified that 10 – 30% of the footprint shown on the Preliminary Site Fit figures is for P-removal. However, this varies by alternative.
    c. 2050 upper flow boundary for the MWWTP, assuming low strength R2 but no high strength R2. No sidestream was included in this analysis.
        i. The Consultant team clarified that the preliminary site fit shows approximate area for the alternative and includes ancillary facilities. It does not take into consideration sequencing nor site layout optimization. Additionally, the peak daily flow of 340 mgd was not used at this level of analysis. That is the estimated peak daily flow if the consent decree is fully implemented.
            1. Yun clarified that EBMUD has analyzed historical flows with and without the consent decree. The flows without the consent decree were used for the screening analysis. Flows with the consent decree will be considered (through sensitivity

analysis) at a later time when we complete detailed analysis of the two shortlisted alternatives.

2. Eileen stated that the consent decree allows operation of the WWF facilities up to 2036. It is assumed blending can continue to occur beyond that point

ii. A few "if" scenarios were also considered during the screening evaluation, one of which included upgrading the Pt Isabel and Oakport WWF for year-round nutrient removal. It was also noted that Pt Isabel does have seasonal and year-round demand for recycled water. However, for the screening evaluation, it was assumed that the treated effluent/sludge from WWFs will be discharged back to the MWWTP

c. Nutrient Screening Results

a. **The seven (7) screened nutrient alternatives to be carried forward for initial evaluation include:**

i. **Alternative 1, HPO + Post Secondary at MWWTP, to be comprised of HPO, secondary clarifiers, BAFs, tertiary clarifiers, and denitrification filters.**

ii. **Alternative 2, Conventional Activated Sludge (CAS) at MWWTP, to be comprised of 5-Stage Bardenpho, secondary clarifiers, and tertiary filters.**

iii. **Alternative 3, Established Intensification Process at the MWWTP, to be comprised of membrane bioreactors/filters (MBRs).**

iv. **Alternative 4, Emerging Technology at the MWWTP, to be comprised of aerobic granular sludge (AGS).**

v. **Alternative 5, Top Ranked MWWTP Technology + Decentralized Treatment, to be comprised of implementing AGS facilities at Oakport and Pt. Isabel to treat average dry weather flow that is discharged to the sewer interceptor.**

vi. **Alternative 6, Existing Process + New Process at the MWWTP, to be comprised of the existing HPO basins and secondary clarifiers, as well as a new process that will treat a portion of the flow.**

vii. **Alternative 7, Established Intensification Process at the MWWTP, to be comprised of IFAS aeration basins, secondary clarifiers, and tertiary filters.**

1. This alternative is a new alternative that EBMUD is interested in developing.

b. Alternative 1 – HPO + Post-Secondary Treatment

i. The recommended technology/configuration for this alternative is HPO, secondary clarifiers, BAFs, tertiary clarifiers, and denitrification filters.

ii. Yun clarified the existing treatment process typically removes about 50% of the phosphorus load. The effluent phosphorus concentration is typically 2 mg/L.

c. Alternative 2 – Conventional Activated Sludge (CAS)

i. The recommended technology/configuration for this alternative is 5-Stage Bardenpho, secondary clarifiers, and tertiary filters.

ii. The Consultant team clarified that all technologies in this categorically failed, except for the 5-Stage Bardenpho alternative because the alternatives do not ultimately achieve anticipated Level 3 nutrient removal requirements. (Note, some technologies can achieve it with significant chemical addition.) Some of these technologies could be an intermediate phase of implementing 5-Stage Bardenpho. That will be considered as part of the implementation plan (i.e., phasing) of this alternative should it ultimately be selected for the basis of the Master Plan.

iii. CAS has a large footprint. Once we do further evaluation, we may find that it doesn't fit. This will be evaluated further in the Initial Alternatives Evaluation task.

d. Alternative 3 – Intensification Process at MWWTP
   i. The recommended technology/configuration for this alternative is membrane bioreactors/filters (MBRs).
   ii. EBMUD expressed that since IFAS is another viable alternative and potentially more cost effective than MBR, IFAS should also be carried forward as a separate alternative. **EBMUD decided that an additional alternative (Alternative 7) should be carried forward with IFAS as the intensification process at the MWWTP.**
   iii. The Consultant team clarified that O&M costs are generally lower for IFAS compared to MBR.
   iv. Cheryl expressed concern that if you take away the midplant, we need to have an alternate plan for controlling flow throughout the plant. This will be considered during detailed evaluation when the site layouts are developed for each alternative.
   v. EBMUD staff stated it is feasible to relocate the existing Maintenance Building, if needed.

e. Alternative 4 – Emerging Technology at MWWTP
   i. The recommended technology/configuration for this alternative is aerobic granular sludge (AGS).
   ii. EBMUD agreed AGS is the most viable emerging technology to carry forward.
   iii. The group discussed whether high rate A/B should be considered. The main benefits of high rate A/B are reported to be potential for reduced footprint and energy usage, as well as the opportunity to implement a B-stage using an emerging technology such as deammonification or nitrite shunt. Also, it may be possible to re-purpose the primary sedimentation tanks to provide clarification in the first step, which could further reduce the footprint. There are a few A/B processes in Europe, but it is not common in the U.S. The main drawbacks are of the process are:
      1. Complexity. There would be two activated sludge processes being operated in series with separate mechanical systems.
      2. Potential for poor sludge settleability. Operation of the first stage at such a high rate could cause poor settleability, as well as operating the second stage with a carbon or nutrient deficit.
      3. Increased need for supplemental carbon compared to more conventional nutrient removal processes.
      4. Potential impacts to digester gas production if primary sedimentation tanks are re-purposed as the first clarification step.
   iv. **EBMUD decided that a high rate A/B technology will not be carried forward due to limited industry experience and the drawbacks discussed.**

1. Consultant Team will provide adequate detail in the Nutrient Alternatives Report on High Rate A/B to capture the discussion that was had in the workshop and to address questions that were asked during the workshop.

v. EBMUD staff commented that they get a thermal gradient, from very cold rain water. This causes wash out of solids. Given that, the Consultant team should be very wary of processes that will decrease settleability.

f. Alternative 5 – Top Ranked MWWTP Technology + Decentralized Treatment
   i. The recommended technology/configuration for this alternative includes implementing AGS facilities at Oakport and Pt. Isabel WWFs.
   ii. **This alternative will be based on treating the average dry weather flow available at these facilities and discharging the secondary effluent and solids to the sewer interceptor.** This alternative will not be based on implementing recycled water, however it will be developed to provide that flexibility in the future
   iii. EBMUD to confirm the average dry weather flow to be used for the Initial Alternatives Evaluation. Current values include 3 mgd for Pt Isabel and 10 mgd for Oakport.
   iv. **The MWWTP technology selected for this alternative will be determined after we complete the initial evaluation of Alternatives 1 – 4 and will be one of the MWWTP technologies from Alternatives 1 – 4.**
   v. EBMUD noted that energy at WWFs is more expensive than at the MWWTP. Additionally, EBMUD noted that burrowing owls may be on the Pt. Isabel site, triggering an environmental impact report. EBMUD confirmed that construction at the Oakport WWF will require pile foundations and that the space shown as available is accurate.
   vi. Eileen expressed that staffing requirements at WWFs is of interest to her due to high labor costs. One option could be to contact out the labor at these decentralized facilities.

g. Alternative 6 – Split Treatment at MWWTP
   i. **This alternative is comprised of the existing HPO basins and secondary clarifiers, as well as a new process that will treat a portion of the flow. The new process technology selected for this alternative will be determined after we complete the initial evaluation of Alternatives 1 – 4 and will be one of the MWWTP technologies from Alternatives 1 – 4.**

Biosolids Management Alternatives Screening

a. Similar to the nutrient screening criteria, the biosolids screening followed the same screening criteria: Ability to meet regulations, technology maturity and risk, ease of permitting, site constraints, and independent operations. An additional screening criterion was added: end use diversification. For a passing score in the end use diversification criterion, the alternative should provide new end use markets beyond status quo (Class B land application and landfill ADC).

b. The current status of SB 1383 was discussed. The bill provides State-wide targets for diversion of organics from landfills: 50% by 2020 and 75% by 2025.

c. The following assumptions were reviewed:
   a. Projected biosolids loads for 2050, without R2. Biosolids projections are based on linear increase with population increase, resulting in approximately 80,000 wet tons/year.

b. The endpoint is based on regulations. This will provide the ability to beneficially reuse biosolids and will help identify a path to produce a Class A product.

d. Biosolids screening results
  a. **The screened solids alternatives to be carried forward for initial evaluation include:**
    i. **Alt 0 – Status Quo**
      1. It was noted by EBMUD staff that this really is only a short-term option. It will eventually morph into Alt. 2
    ii. **Alt 1 – Pre-digestion, Class A Cake (Bookend)**
    iii. **Alt 2 – 100% to Merchant Facilities**
    iv. **Alt 3 – 100% to Post Digestion, Class A Product (Thermal Drying)**
    v. **Alt 4 – 50% to Post Digestion, Class A Product (Pyrolysis and TCHP Lystek) (Need to optimize the right %)**
  b. Alternative 0 - Status Quo:
    i. This alternative reflects EBMUD's current biosolids practices. The majority of biosolids is going to land application. EBMUD has reduced amount of biosolids going to landfill, thus there has been a rise in cost of biosolids management due to wet weather. Carol also noted that late rains affect when the trucks can go land apply, so there are times outside of wet weather season that the biosolids must be diverted.
  c. Alternative 0A-modified status quo with Class A cake
    i. This alternative would consider temperature-phased anaerobic digestion, thermophilic batch, or high solids digestion technologies to produce Class A cake. Based on the market assessment, there is no driver to go to Class A cake. The cake currently produced is odorous and "sticky," which is undesirable to various markets. It is uncertain if new technologies can improve the aesthetics of the cake. **EBMUD decided that this alternative can be eliminated since there is no driver to produce Class A cake.**
  d. Alternative 1- Class A Cake, Pre-Digestion at EBMUD Property
    i. This alternative would consider a technology such as Cambi to produce Class A cake. A Cambi cake may open new markets, may help dewaterability and provide additional digester capacity with the existing digesters. Although the driver to go to this alternative is not due to Class A cake profitability, this option may be viable if capacity analysis finds that additional digester capacity is needed in the future.
      1. Yun noted that existing VSR is approximately 70%, so it is also uncertain how much more capacity a Cambi technology could provide
    ii. The Consultant team noted that although SFPUC is moving to produce a Cambi Class A cake, the market is fairly large across the bay area and is not expected to be saturated from the future SFPUC Cambi product.
    iii. **EBMUD would like to move forward with this alternative, considering the Cambi technology as the placeholder technology.**
  e. Alternative 2- Class B cake and haul 100% to merchant facility
    i. This alternative would include a long-term contact agreement with a merchant facility for a fixed price. Although this option may be more

expensive than what EBMUD is paying now to dispose of the solids, this option would provide certainty of the disposal of the solids.

ii. There are various merchant facilities entering the market due to the demand.

iii. **The Consultant team will include sludge screening in this alternative.** Due to the debris in the sludge, sludge screening will ensure the market value of the product and consistency for merchant facilities.

iv. Cheryl asked if there has been some thought of reuse of biosolids for land reclaimed use. The Consultant team has considered this option, Region 9 has expressed that Class A biosolids must be used for land reclamation. Additionally, the land reclamation market need fluctuates, so it is not recommended to build a biosolids management program around this type of end use.

   1. Eileen noted that there has been a WRF study on the use of biosolids for land reclamation.

v. **EBMUD would like to move forward with this alternative, however they want this alternative to include multiple facilities for diversification.** The Consultant team will make this change to the alternative.

f. Alternative 3- Class A Product, 100% Post-Digestion Technology at EBMUD Property

i. This option would be paired with post digestion technologies such as solar drying, drying beds, TCHP, or composting to achieve Class A. Of the technologies considered, thermal drying opens fertilizer blending opportunities and composting and pyrolysis/gasification opens soil blending and horticulture. Composting, however, is a tough market to enter due to competition with organic fertilizers. Gasification failed the screening criteria due to technology status. There are only small facilities in operation in the US, none is operating at the same size as EBMUD.

   1. Maura asked if there are any issues with emissions with thermal dryers. The Consultant team confirmed that thermal dryers will need some air pollution devices, the dryers can run on biogas, natural gas or waste heat. No regulatory issues are expected with thermal dryers.

ii. **EBMUD would like to move forward with this alternative considering thermal drying as the placeholder technology.**

g. Alternative 4- Class A Product, 50% Post-Digestion

i. During dry season, 50% of biosolids would be treated at EBMUD post digestion and the remaining 50% would be land applied. During wet weather, 50% of biosolids would still be treated at EBMUD post digestion, and the remaining 50% would be sent to an off-site merchant facility.

ii. For initial screening, this alternative assumed 50% of biosolids would be treated post digestion year-round. The percent diverted to post digestion treatment will be refined in the alternatives analysis.

iii. In this alternative, a pyrolysis technology (Bioforce Tech) passes the screening criteria. In this scenario, the pyrolysis unit needed is smaller than Alternative 3. Similar sized units are in operation at SVCW.

iv. **EBMUD would like to move forward with this alternative, considering pyrolysis as the placeholder technology on site at EBMUD (year-round) and Lystek for off-site treatment during wet weather.**

e. General considerations:
    a. <u>The Consultant team will document the reasons why technologies discussed in this workshop were screened out.</u>
    b. The Board is very interested in sustainable, GHG reduction, etc. It is important to EBMUD to reduce their nitrogen impact and get nutrient savings from reducing GHG emissions at the plant.
    c. **There is no interest in having EBMUD become a regional biosolids facility because there is concern that the neighborhood impacts would be too severe.**
    d. **EBMUD confirmed that there is no interest in looking into the Pinole site for composting operations.**
    e. Odors
        i. Cheryl mentioned significant odor control concerns about Biosolids Alternatives 3 and 4. The plant can reasonably control liquid odors but can't very successfully control gaseous odors.
            1. Given odors are such an issue, trucking the biosolids elsewhere may be required. Otherwise, EBMUD is concerned about a possible negative impact on nearby residents.
    f. EBMUD agreed that in order to secure biosolids land application in the future, the MWWTP must continue to improve the quality and marketing of the biosolids.

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APPENDIX D – TECHNOLOGY INSTALLATION LIST

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This appendix provides a summary of facilities for pyrolysis (Table D-1), Lystek (Table D-2), and thermal dryers (Table D-3)

Table D-1. List of pyrolysis facilities

Location	Feedstock	Scale	Status	Capacity (WT)/Year
Linden, New Jersey	Biosolids	Full-scale	Q4 2020	130,000
Redwood city, California	Biosolids	Full-scale	2017	7,000
Edmonds, Washington	Biosolids	Full-scale	2021	unknown
San Bernardino, California	Biosolids/foodwaste (70%)	Full-scale	2020	109,500
Carlsbad, California	Biosolids	Pilot/Demonstration	2014	unknown
Carson, California	Biosolids	Pilot/Demonstration	2008-2015	1,000
San Bernardino, California	Biosolids	Full-scale	2020	7,950

Table D-2 List of Lystek Facilities

Location	Status	Capacity (WT/Y)	Location	LysteMize Digester Enhancement	LysteCarb Carbon Source for BNR
Guelph	2008	18,000	On Site	Full Scale Pilot	No
St. Mary's	2010	3,500	On Site	Full Scale	Yes
Southgate	2012	150,000	Off Site	Merchant Plant (No Digestion)	No
Iroquois	2012	40,000	Off Site	Merchant Plant (No Digestion)	No
Elora	2014	3,500	On Site	Aerobic Digestion	No
North Battleford	2014	3,500	On Site	Aerobic Digestion	No
Fairfield, California	2016	150,000	On Site	Full Scale	No
St. Thomas	2017	5,600	On Site	No	No
Innisfil	2018	5,500	On Site	Aerobic Digestion	No

Table D-3 Andritz North America Drum Dryer Installations

Award	Client	Plant Location	Country	Evaporation Capacity kg H2O/
2017	Harbour City Solutions	Hamilton, ON	Canada	7.0
2011	Irvine Ranch Water District	Irvine, CA	USA	6.0
2011	Upper Occoquan Sewage Authority	Centreville, VA	USA	4.0
2010	City of Tallahassee	Tallahassee, FL	USA	5.0
2009	Synagro Technologies Inc. for City of Philadelphia	Philadelphia, PA	USA	2x12.0
2009	City of Waco Texas, USA	Waco Texas	USA	1x4.000
2006	Manatee County	Bradenton, FL	USA	6.0
2006	Stamford Water Pollution Control Authority	Stamford, CT	USA	4.0
2005	Archer Weston/EarthTech Joint Venture	Nashville and Davidson County, TN	USA	2x8.0
2005	Almeda Sims WWTP	City of Houston, TX	USA	2x8.0
2005	Archie Elledge Wastewater Treatment Plant	Winston - Salem, NC	USA	6.0
2005	Hillsborough County	Tampa, FL	USA	2x5.0
2004	Encina Water Pollution Control Facility	Carlsbad, CA	USA	1x4.000
2004	Bonita Springs Utilities	Bonita Springs/FL	USA	1x2.000
2004	Pierce County	Pierce/WA	USA	1x2.000
2004	Town of Cary	Cary/NC	USA	1x4.000
2002	Synagro Technologies Inc. for Sacramento WWTP	Sacramento/CA	USA	1x4.000
2002	Synagro for Pinellas County Utilities	St. Petersburg/FL	USA	1x4.000
2002	Synagro Technologies Inc. for City and County of Honolulu	Honolulu, HI	USA	1x4.001
2000	JEA	Jacksonville/FL	USA	1x7.400
2000	Louisville and Jefferson Counties MSD	Louisville/KY	USA	4x8.500
2000	Town of Leesburg	Leesburg/VA	USA	1x2.000

Award	Client	Plant Location	Country	Evaporation Capacity kg H2O/
1999	Aiken County Public Service Authority	Aiken, SC	USA	1x4.000
1996	Sumter Wastewater Treatment Plant	Sumter/SC	USA	1x4.300
1995	Ocean County Utility Authority	Bayville/NJ	USA	2x4.000
1995	Amherst Wastewater Treatment Plant	Amherst, NY	USA	1 x 2.000
1994	Brazos River Authority	Waco, TX	USA	1x4.000

APPENDIX E – FLOWS AND LOADS

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This appendix provides the average dry weather (ADW), maximum month (MM) and maximum day (MD) flows and loads to the system. Further details regarding the BioWin model results and solids peaking factors are in the C70 Capacity Assessment report.

Table E-1. Summary of Projected Flows and Loads [a]

	2020	2030	2040	2050
Blend Tank Effluent (Digester Influent)				
ADW Flow, mgd	0.80	0.80	0.90	1.00
ADW, TS lbs/day	297,000	329,000	364,000	405,000
ADW, VS lbs/day	222,000	246,000	273,000	304,000
MM Flow, mgd	0.90	1.00	1.10	1.20
MM, TS lbs/day	368,000	408,000	452,000	502,000
MM, VS lbs/day	313,000	348,000	386,000	429,000
MD Flow, mgd	1.20	1.30	1.40	1.60
MD, TS lbs/day	614,000	682,000	754,000	838,000
MD, VS lbs/day	562,000	625,000	693,000	771,000
Digested Sludge (Digester Effluent)				
ADW Flow, mgd	0.80	0.80	0.90	1.00
ADW, TS lbs/day	137,000	153,000	171,000	191,000
ADW, VSS lbs/day	87,000	99,000	111,000	126,000
MM Flow, mgd	1.00	1.00	1.10	1.30
MM, TS lbs/day	181,000	202,000	225,000	252,000
MM, VS lbs/day	104,000	117,000	133,000	150,000
MD Flow, mgd	1.40	1.60	1.70	1.90
MD, TS lbs/day	247,000	276,000	307,000	344,000
MD, VS lbs/day	150,000	170,000	192,000	218,000
a. All values are rounded to the nearest thousandth.				

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APPENDIX F – CAPITAL AND OPERATING COSTS

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Table F-1 Summary of Operation and Maintenance Unit Costs

Item	Cost	Units	Notes
Annual Operating Costs			
Energy Costs			
at MWWTP (WAPA)	$0.10	kWh	Existing with demand charges rolled in
PG&E Electricity at MWWTP	$0.17	kWh	If MWWTP converted to PG&E power
PG&E at Pt. Isabel	$0.22	kWh	Existing with demand charges rolled in
PG&E at Oakport	$0.22	kWh	Existing with demand charges rolled in; assumes that existing agreement is modified to match Pt. Isabel agreement.
Natural Gas			
Natural gas cost at all facilities	$10.00	/MMBtu	
Water			
Recycled water	$5,005	$/MG	based on 2018 data
Potable water	$6,252	$/MG	based on 2018 data
Chemicals			
Citric acid (50% solution)	$7.00	$/gallon	from Bay Area Consortium
45% caustic potash (liquid sol'n)	$0.34	$/lb (wet)	Assumed to be the same price NaOH
Steam Chemical (THP)	$0.0033	$/gallon	Assumed based on previous OCSD project
Polymer (neat solution)	$1.21	$/lb (wet)	District purchase order
Replacement and Rehab			
Annual equipment maintenance	2%	of equipment costs	
Annual Licensing fees			
Lystek Merchant Facility	$50,000	$/yr	per vendor
Labor			
Hourly O&M Rate	$147	/hour	

Item	Cost	Units	Notes
Annual Operating Costs			
Biosolids Management			
Land Application	$34	/wet ton	Dry Weather Hauling and land application historical price.
WW Hauling for ADC, Compost, or storage/land app	$64	/wet ton	Wet weather hauling and tipping fee based on historical price.
Lystek Merchant Facility	$100	/wet ton	Wet weather hauling and tipping fee based on historical price.
Annual Revenue			
Excess Power Revenue			
Sale of Excess Power	$0.058	$/kWh	$0.058/kwh includes ~$0.012/kwh for the RECs sold to the Port of Oakland. R2 expects this to drop in the future. Assuming ~$0.040/kwh may be more reasonable starting from 2030.
Biosolids Revenue			
Biosolids Pellets	$12	$ /ton (net value)	From Market Assessment Report ($15/wt with 20% broker fee)
Biosolids Biochar	$8	$ /ton (net value)	From Market Assessment Report ($10/wt with 20% broker fee)
Net Present Value Assumptions			
Time period	30	years	Time period TBD
Inflation rate	3%		Biosolids management, electricity and R2 tipping fees will escalate at different rates - TBD
Nominal Discount Rate	5%		
Real Discount Rate	2%		
Salvage Value for Equipment	---	Not included	
Equipment Useful Life	30	years	
Escalation Rate for Construction Costs (Midpoint)	4%	per year	

Table F-2. Summary of Assumptions used in the SWEET Model

Item	Value	Units	Notes
Non-cost Assumptions			
THP and Ancillary Equipment			
Boiler Efficiency for THP	85%	%	Assumed based on various steam boiler data sheets
Heat required for steam generation (Btu/lb steam)	1196.5	BTU/lb steam	Steam tables
Pre-dewatering Power Requirement	0.00261	HP/lb solids load	based on THP power calcs created on previous projects (saved in reference)
THP Power Requirement	0.00116	HP/lb solids load	based on THP power calcs created on previous projects (saved in reference)
Dryers			
Make up water	1	ratio of makeup water to water evaporated	vendor
Heat value of gas			
LHV biogas	560	BTU/cf	based on typical value of biogas
ratio of HHV to LHV	1.1	HHV:LHV	
Plant Electrical Demand			
Plant demand	0.00003	MW/lb-BOD	Based on 2018 demand of 4.4MW
2020 BOD influent load	170,197	lb-BOD/d	Biowin results
2050 BOD influent load	246,036	lb-BOD/d	Biowin results
HPO electrical demand	3.3	kWh	provided by Mallika
Start of HPO electrical demand	2030	year	
Dewatering			
Normal Polymer Dose/use	29.0	lb-poly active/dry ton sludge	Based on historical plant data
Lystek Polymer Dose/use	14.5	lb-poly active/dry ton sludge	Assumed - use 50% less polymer
Pre-Dewatering Polymer Dose/use	14.5	lb-poly active/dry ton sludge	Assumed - use 50% less polymer

Item	Value	Units	Notes
Lystek and Ancillary Equipment			
Electrical	73.0	HP/dt	Provided by vendor (60kW-h/dt)
Heating requirements	1.1	MMBtu/dt	Provided by vendor
45% caustic NaOH (liquid sol'n)	190.0	lbs Sol'n/dt	Provided by vendor
water demand in boilers	4.0	gpm	Provided by vendor
Pyrolysis and Ancillary Equipment			
Electrical	124.5	HP/wt	Provided by vendor (55kW-h/wt)
Heating requirements	3000.0	therms/startup	Provided by vendor; used for startup of 1 machine
Heating requirements	300.0	mmbtu/startup	Provided by vendor; used for startup of 1 machine
Maintenance	500.0	hours/yr	Provided by vendor (accounted for in FTE estimate)
Thermal Energy produced	1.5	Mmbtu/hr-train	Provided by vendor
water required	0.2	gpm/unit	Provided by vendor
FTE Requirements			
Alt S1	6.0	FTEs	Assumed based on knowledge of system and its operation
Alt S2	5.0	FTEs	Provide by vendor
Alt S4A	5.0	FTEs	Assumed based on knowledge of system and its operation
Alt S4B	2.5	FTEs	Assumed half of 100% Lystek
Alt S5 - 2050	5.0	FTEs	Assumed similar to dryer

Capital Cost Estimates

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Blend Tank Screening Cost Estimate				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Enclosed Solids Screening	$ 2,000,000 $/unit	1 unit	$ 2,000,000	
Odor Control for Screening Facility				
Fittings; Dampers	$ 42,300 $/ea	1 ea	$ 42,300	Per D. McEwen
HDPE Chemical Storage tank; 1000 gal tank	$ 6,000 $/ea	1 gallons	$ 6,000	Per D. McEwen; scaled based on size of building
FRP ductwork: 48-inch diameter duct	$ 365 $/LF	8 lf	$ 2,920	Per D. McEwen
Odor Control Scrubber	$ 100,000 LS	1 EA	$ 100,000	Per D. McEwen; scaled based on size of building
Admin Building				
Excavation for Building	$ 20 $CY	390 CY	$ 7,800	
Subgrade	$ 10 $CY	130 CY	$ 1,300	
Soil Disposal - Non-RCRA	$ 50 $/ton	340 ton	$ 17,000	
Pile Foundation	$ 95 $/VLF	9,100 VLF	$ 864,500	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	180 CY	$ 162,000	
Subtotal A			$ 3,204,000	
Misc. Demolition	5% of "A"		$ 160,200	
Civil	5% of "A"		$ 160,200	
Yard Piping	12% of "A"		$ 384,480	
HVAC	5% of "A"		$ 160,200	
Shoring and Dewatering	10% of "A"		$ 320,400	
Electrical, Instrumentation & Controls	25% of "A"		$ 801,000	
Hazardous Materials and Handling	5% of "A"		$ 160,200	
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"		$ 160,200	
Subtotal B			$ 5,500,000	
Startup and Construction Sequencing	12% of "B"		$ 660,000	
Construction Easements	5% of "B"		$ 275,000	
General Conditions	10% of "B"		$ 550,000	
Contractor Overhead and Profit	10% of "B"		$ 550,000	
Sales Tax	9% 1/2 of "B"		$ 247,500	
Subtotal C Construction Costs			$ 7,800,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 7,800,000	
Change Order Contingency (10% if less than $50M)	10% of construction costs w/Market Factor		$ 780,000	
Total Construction Costs			**$ 8,580,000**	
Planning and Permitting	10% of total construction costs		$ 858,000	
Engineering	15% of total construction costs		$ 1,287,000	
Construction Management	15% of total construction costs		$ 1,287,000	
Subtotal Project Costs			$ 12,000,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 3,600,000	
Total Project Cost			**$ 15,600,000**	

All costs presented in 2020 dollars.
All costs are rounded.

Digester Rehab Cost Estimate				
Item	Unit Cost	Units	Class V Total	Notes
Seismic rehab for second-stage digesters	$ 1,150,000 $/ea	3 ea	$ 3,588,000	Modified costs based on EBMUD estimates of what is in CIP, escalated to 2019 dollars assuming 4 percent per year increase
Subtotal A			$ 3,588,000	
Misc. Demolition	5% of "A"		$ 179,400	
Civil	5% of "A"		$ 179,400	
Yard Piping	0% of "A"		$ -	
HVAC	0% of "A"		$ -	
Shoring and Dewatering	10% of "A"		$ 358,800	
Electrical, Instrumentation & Controls	0% of "A"		$ -	Assume limited to no electrical or I&C included in project
Hazardous Materials and Handling	5% of "A"		$ 179,400	
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"		$ 179,400	
Subtotal B			$ 4,700,000	
Startup and Construction Sequencing	15% of "B"		$ 705,000	Higher percentage assumed for extended schedule (1 digester rehab per year)
Construction Easements	5% of "B"		$ 235,000	
General Conditions	10% of "B"		$ 470,000	
Contractor Overhead and Profit	10% of "B"		$ 470,000	
Sales Tax	9% 1/2 of "B"		$ 211,500	
Subtotal C Construction Costs			$ 6,800,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 6,800,000	
Change Order Contingency (10% if less than $50M)	10% of construction costs w/Market Factor		$ 680,000	Increased to 10% b/c construction cost is < $50M)
Total Construction Costs			$ 7,480,000	
Planning and Permitting	5% of total construction costs		$ 374,000	
Engineering	15% of total construction costs		$ 1,122,000	
Construction Management	15% of total construction costs		$ 1,122,000	
Subtotal Project Costs			$ 10,100,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 3,030,000	
Total Project Cost			$ 13,100,000	

Total Project Cost Matches CIP Digester Phase 4 costs, escalated to 2019 dollars.
All costs presented in 2020 dollars.
All costs are rounded.

Merced Winter Storage (6 Months)				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Enclosed Cake storage	$22,500,000 $/unit	1 unit	$ 22,500,000	This is the adjusted raw cost from previous estimate for 31,250 cy for 4-months of storage
Merced Property	$ 20,000 $/ac	5 ac	$ 100,000	minimum land required for storage
Odor Control for Cake Storage				
Fittings; Dampers	$ 42,300 $/ea	1 ea	$ 42,300	Per D. McEwen
HDPE Chemical Storage tank; 1000 gal tank	$ 6,000 $/ea	2 gallons	$ 12,000	Per D. McEwen
FRP ductwork: 300 LF of 48-inch diameter duct	$ 365 $/LF	300 lf	$ 109,500	Per D. McEwen
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation)	$ 1,252,000 $/ea	1 ea	$ 1,252,000	Per D. McEwen
Admin Building				
Excavation for Building	$ 20 $CY	70 CY	$ 1,400	
Subgrade	$ 10 $CY	70 CY	$ 700	
Soil Disposal - Non-RCRA	$ 50 $/ton	60 ton	$ 3,000	
Pile Foundation	$ 95 $/VLF	1,560 VLF	$ 148,200	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	30 CY	$ 27,000	
Building costs	$ 450 $/SF	600 SQFT	$ 270,000	
Paved areas	$ 10 $/SF	110,000 SQFT	$ 1,100,000	
Subtotal A			$ 25,566,100	
Misc. Demolition	5% of "A"		$ 1,278,305	Leave allowance b/c unknown site conditions
Civil	5% of "A"		$ 1,278,305	
Yard Piping	12% of "A"		$ 3,067,932	
HVAC	5% of "A"		$ 1,278,305	
Shoring and Dewatering	5% of "A"		$ 1,278,305	Reduced allowance b/c limited below grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 6,391,525	
Hazardous Materials and Handling	0% of "A"		$ -	Assume no haz. materials are present at site
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"		$ 1,278,305	
Subtotal B			$ 41,400,000	
Startup and Construction Sequencing	12% of "B"		$ 4,968,000	
Construction Easements	5% of "B"		$ 2,070,000	
General Conditions	10% of "B"		$ 4,140,000	
Contractor Overhead and Profit	10% of "B"		$ 4,140,000	
Sales Tax	9% 1/2 of "B"		$ 1,863,000	
Subtotal C Construction Costs			$ 58,600,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 58,600,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor		$ 2,930,000	
Total Construction Costs			$ 61,530,000	
Planning and Permitting	8% of total construction costs		$ 4,922,400	Changed to 8% for potenital community/mitigation factors
Engineering	15% of total construction costs		$ 9,229,500	
Construction Management	15% of total construction costs		$ 9,229,500	
Subtotal Project Costs			$ 84,900,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 25,470,000	
Total Project Cost			$ 110,400,000	

All costs presented in 2020 dollars.
All costs are rounded.

Pinole Winter Storage (6 Months)				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Enclosed Cake storage	$ 22,500,000 $/unit	1 unit	$ 22,500,000	This is the adjusted raw cost from previous estimate for 31,250 cy for 4-months of storage
Odor Control for Cake Storage				
Fittings; Dampers	$ 42,300 $/ea	1 ea	$ 42,300	Per D. McEwen
HDPE Chemical Storage tank; 1000 gal tank	$ 6,000 $/ea	2 gallons	$ 12,000	Per D. McEwen
FRP ductwork: 300 LF of 48-inch diameter duct	$ 365 $/LF	300 lf	$ 109,500	Per D. McEwen
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation)	$ 1,252,000 $/ea	1 ea	$ 1,252,000	From D. McEwen - from other projects; scaled from 4 months storage
Admin Building				
Excavation for Building	$ 20 $CY	70 CY	$ 1,400	
Subgrade	$ 10 $CY	70 CY	$ 700	
Soil Disposal - Non-RCRA	$ 50 $/ton	60 ton	$ 3,000	
Pile Foundation	$ 95 $/VLF	1,560 VLF	$ 148,200	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	30 CY	$ 27,000	
Building costs	$ 450 $/SF	600 SQFT	$ 270,000	
Paved areas	$ 10 $/SF	110,000 SQFT	$ 1,100,000	
Subtotal A			$ 25,466,100	
Misc. Demolition	5% of "A"		$ 1,273,305	Leave allowance b/c unknown site conditions
Civil	5% of "A"		$ 1,273,305	
Yard Piping	12% of "A"		$ 3,055,932	
HVAC	5% of "A"		$ 1,273,305	
Shoring and Dewatering	5% of "A"		$ 1,273,305	Reduced allowance b/c limited below grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 6,366,525	
Hazardous Materials and Handling	0% of "A"		$ -	Assume no haz. materials are present at site
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"		$ 1,273,305	
Subtotal B			$ 41,300,000	
Startup and Construction Sequencing	12% of "B"		$ 4,956,000	
Construction Easements	5% of "B"		$ 2,065,000	
General Conditions	10% of "B"		$ 4,130,000	
Contractor Overhead and Profit	10% of "B"		$ 4,130,000	
Sales Tax	9% 1/2 of "B"		$ 1,858,500	
Subtotal C Construction Costs			$ 58,400,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 58,400,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor		$ 2,920,000	
Total Construction Costs			$ 61,320,000	
Planning and Permitting	10% of total construction costs		$ 6,132,000	Changed to 10% for potenital community/mitigation factors
Engineering	15% of total construction costs		$ 9,198,000	
Construction Management	15% of total construction costs		$ 9,198,000	
Subtotal Project Costs			$ 85,800,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 25,740,000	
Total Project Cost			$ 111,500,000	

All costs presented in 2020 dollars.
All costs are rounded.

Pinole Winter Storage (4 Months)				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Enclosed Cake Storage	$15,000,000 $/unit	1 unit	$ 15,000,000	Building square footage = 100,000 sqft
Odor Control for Cake Storage				
Fittings; Dampers	$ 42,300 $/ea	1 ea	$ 42,300	Per D. McEwen
HDPE Chemical Storage tank; 1000 gal tank	$ 6,000 $/ea	2 gallons	$ 12,000	Per D. McEwen
FRP ductwork: 300 LF of 48-inch diameter duct	$ 365 $/LF	300 lf	$ 109,500	Per D. McEwen
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation)	$ 810,000 $/ea	1 ea	$ 810,000	
Admin Building				
Excavation for Building	$ 20 $CY	70 CY	$ 1,400	
Subgrade	$ 10 $CY	70 CY	$ 700	
Soil Disposal - Non-RCRA	$ 50 $/ton	60 ton	$ 3,000	
Pile Foundation	$ 95 $/VLF	1,560 VLF	$ 148,200	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	30 CY	$ 27,000	
Building costs	$ 450 $/SF	600 SQFT	$ 270,000	
Paved areas	$ 10 $/SF	110,000 SQFT	$ 1,100,000	
Subtotal A			$ 17,524,100	
Misc. Demolition	5% of "A"		$ 876,205	Leave allowance b/c unknown site conditions
Civil	5% of "A"		$ 876,205	
Yard Piping	12% of "A"		$ 2,102,892	
HVAC	5% of "A"		$ 876,205	
Shoring and Dewatering	5% of "A"		$ 876,205	Reduced allowance b/c limited below grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 4,381,025	
Hazardous Materials and Handling	0% of "A"		$ -	Assume no haz. materials are present at site
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"		$ 876,205	
Subtotal B			$ 28,400,000	
Startup and Construction Sequencing	12% of "B"		$ 3,408,000	
Construction Easements	5% of "B"		$ 1,420,000	
General Conditions	10% of "B"		$ 2,840,000	
Contractor Overhead and Profit	10% of "B"		$ 2,840,000	
Sales Tax	9% 1/2 of "B"		$ 1,278,000	
Subtotal C Construction Costs			$ 40,200,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 40,200,000	
Change Order Contingency (10% if less than $50M)	10% of construction costs w/Market Factor		$ 4,020,000	Increased percentage to 10 b/c construction costs are <$50M
Total Construction Costs			$ 44,220,000	
Planning and Permitting	10% of total construction costs		$ 4,422,000	Changed to 10% for potenital community/mitigation factors
Engineering	15% of total construction costs		$ 6,633,000	
Construction Management	15% of total construction costs		$ 6,633,000	
Subtotal Project Costs			$ 61,900,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 18,570,000	
Total Project Cost			$ 80,500,000	

All costs presented in 2020 dollars.
All costs are rounded.

Pinole Winter Storage (2 months)					
Item	**Unit Cost**		**Units**	**Class V Total**	**Notes**
Cake storage - 2 months	$ 7,500,000	$/unit	1 unit	$ 7,500,000	Building square footage = 60,000 sqft
Odor Control for Cake Storage					
Fittings; Dampers	$ 42,300	$/ea	1 ea	$ 42,300	From D. McEwen - from other projects
HDPE Chemical Storage tank; 1000 gal tank	$ 6,000	$/ea	1 gallons	$ 6,000	From D. McEwen - from other projects
FRP ductwork: 300 LF of 48-inch diameter duct	$ 365	$/LF	300 lf	$ 109,500	From D. McEwen - from other projects
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation)	$ 442,000	$/ea	1 ea	$ 442,000	From D. McEwen - from other projects; scaled from 4 months storage
Admin Building					
Excavation for Building	$ 20	$CY	70 CY	$ 1,400	
Subgrade	$ 10	$CY	70 CY	$ 700	
Soil Disposal - Non-RCRA	$ 50	$/ton	60 ton	$ 3,000	
Pile Foundation	$ 95	$/VLF	1,560 VLF	$ 148,200	
Concrete Slab, at grade, 16-inch	$ 900	$/CY	30 CY	$ 27,000	
Building costs	$ 450	$/SF	600 SQFT	$ 270,000	
Paved areas	$ 10	$/SF	110,000 SQFT	$ 1,100,000	
Subtotal A				$ 9,650,100	
Misc. Demolition	5%	of "A"		$ 482,505	Leave allowance b/c unknown site conditions
Civil	5%	of "A"		$ 482,505	
Yard Piping	12%	of "A"		$ 1,158,012	
HVAC	5%	of "A"		$ 482,505	
Shoring and Dewatering	5%	of "A"		$ 482,505	Reduced allowance b/c limited below grade construction
Electrical, Instrumentation & Controls	25%	of "A"		$ 2,412,525	
Hazardous Materials and Handling	0%	of "A"		$ -	Assume no haz. materials are present at site
Misc. Excavated Soil Disposal (not deep or special excavations)	5%	of "A"		$ 482,505	
Subtotal B				$ 15,600,000	
Startup and Construction Sequencing	12%	of "B"		$ 1,872,000	
Construction Easements	5%	of "B"		$ 780,000	
General Conditions	10%	of "B"		$ 1,560,000	
Contractor Overhead and Profit	10%	of "B"		$ 1,560,000	
Sales Tax	9%	1/2 of "B"		$ 702,000	
Subtotal C Construction Costs				$ 22,100,000	
Market Factor	0%	of "C"		$ -	
Construction Costs with Market Factor				$ 22,100,000	
Change Order Contingency (10% if less than $50M)	10%	of construction costs w/Market Factor		$ 2,210,000	Increased percentage to 10 b/c construction costs are <$50M
Total Construction Costs				$ 24,310,000	
Planning and Permitting	10%	of total construction costs		$ 2,431,000	Changed to 10% for potenital community/mitigation factors
Engineering	15%	of total construction costs		$ 3,646,500	
Construction Management	15%	of total construction costs		$ 3,646,500	
Subtotal Project Costs				$ 34,000,000	
Estimating Contingency (includes market factor contingency)	30%	of subtotal Project Costs		$ 10,200,000	
Total Project Cost				$ 44,200,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 2: THP System				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
THP System				Scaled from King County Project - costs include building and earthwork
Solids Screening and Pre-dewatering	$ 117,334,400 $/ea	1 ea	$ 117,334,400	
Thermal Hydrolysis (CAMBI)	$ 74,311,800 $/ea	1 ea	$ 74,311,800	
Steam Boilers	$ 11,049,000 $/ea	1 ea	$ 11,049,000	
Cooling Towers	$ 6,551,200 $/ea	1 ea	$ 6,551,200	
Enclosed Cake Storage	$ 15,000,000 $/unit	- unit	$ -	This is the adjusted raw cost from previous estimate for 31,250 cy for 4-months of storage
Odor Control for Cake Storage (4 months)				
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation): LS $810,000	$ 810,000 $/ea	- ea	$ -	
Stainless steel chemical storage tank: 1,700 gallon capacity, 1 tank total	$ 46 $/gal	- gallons	$ -	
FRP ductwork: 300 LF of 48-inch diameter duct	$ 200 $/LF	- lf	$ -	
Subtotal A			$ 209,246,400	
Misc. Demolition	5% of "A"			already included in base number
Civil	5% of "A"			
Yard Piping	12% of "A"			
HVAC	5% of "A"			
Shoring and Dewatering	10% of "A"		$ 20,924,640	to include allowance for pile foundation
Electrical, Instrumentation & Controls	25% of "A"			
Hazardous Materials and Handling	5% of "A"			
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"			
Subtotal B			$ 230,200,000	
Startup and Construction Sequencing	12% of "B"		$ 27,624,000	
Construction Easements	5% of "B"		$ 11,510,000	
General Conditions	10% of "B"		$ 23,020,000	
Contractor Overhead and Profit	10% of "B"		$ 23,020,000	
Sales Tax	9% 1/2 of "B"		$ 10,359,000	
Subtotal C Construction Costs			$ 325,700,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 325,700,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor		$ 16,285,000	
Total Construction Costs			$ 341,985,000	
Planning and Permitting	5% of total construction costs		$ 17,099,250	
Engineering	15% of total construction costs		$ 51,297,750	
Construction Management	15% of total construction costs		$ 51,297,750	
Subtotal Project Costs			$ 461,700,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 138,510,000	
Total Project Cost			$ 600,200,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 3A: Thermal Dryers						
Item	**Unit Cost**		**Units**		**Class V Total**	**Notes**
Andritz Drum Equipment Package	$ 24,938,000	$/pkg	1	pkg	$ 24,938,000	Includes 2 dryers, drive through silos & platforms. Also includes package odor control system
Installation	$ 9,975,200	$/pkg	1	pkg	$ 9,975,200	Silos accounts for Storage
Pellet Storage for 4 Months	$ 13,800,000	LS	1	LS	$ 13,800,000	4 months storage
Building for Thermal Dryer						
Excavation for Building	$ 20	$CY	2810	CY	$ 56,200	
Subgrade	$ 10	$CY	940	CY	$ 9,400	
Soil Disposal - Non-RCRA	$ 50	$/ton	2390	ton	$ 119,500	
Pile Foundation	$ 95	$/VLF	65,730	VLF	$ 6,244,350	
Concrete Slab, at grade, 16-inch	$ 900	$/CY	1250	CY	$ 1,125,000	
Building Costs	$ 625	$/SF	25,280	SF	$ 15,800,000	includes space for dewatering centrifuges (4 D7LL units - 2 duty, 2 standby at annual operating conditions). Dewatering footprint (3rd floor) removed from estimate
Silo/Storage and Truck Off-Load Facility						includes dust control, instrumentation in manufacturer quote
Excavation	$ 20	$CY	1290	CY	$ 25,800	
Subgrade	$ 10	$CY	430	CY	$ 4,300	
Soil Disposal - Non-RCRA	$ 50	$/ton	1100	ton	$ 55,000	
Pile Foundation	$ 95	$/VLF	29,990	VLF	$ 2,849,050	
Concrete Slab, at grade, 16-inch	$ 900	$/CY	570	CY	$ 513,000	
Miscellaneous						
18" shaftless screw conveyor 316SS, installed, no controls	$ 2,400	$/LF	800	LF	$ 1,920,000	
Controls for Screw Conveyors	$ 15,000	$/ea	1	ea	$ 15,000	
8in DI - Digested Sludge Pipeline	$ 200	$/LF	1,000	LF	$ 200,000	
Allowance for New Digested Sludge Pumps (PD Pump)	$ 1,650	$/HP (up to 50	200	hp	$ 330,000	assumes 4, 50 hp pumps
Subtotal A					$ 77,979,800	
Misc. Demolition	0%	of "A"			$ -	Eliminated b/c it assumes open site - no existing building
Civil	5%	of "A"			$ 3,898,990	
Yard Piping	2%	of "A"			$ 1,559,596	Reduced percentage b/c DS and screw conveyors above; additional piping needed for condensate/plant drain connection
HVAC	5%	of "A"			$ 3,898,990	
Shoring and Dewatering	5%	of "A"			$ 3,898,990	Reduced b/c minimal below-grade construction
Electrical, Instrumentation & Controls	25%	of "A"			$ 19,494,950	
Hazardous Materials and Handling	0%	of "A"			$ -	Eliminated b/c it assumes open site - no existing building
Misc. Excavated Soil Disposal (not deep or special excavations)	1%	of "A"			$ 584,849	Allowance for miscellaneous yard piping excavation
Subtotal B					$ 111,300,000	
Startup and Construction Sequencing	12%	of "B"			$ 13,356,000	
Construction Easements	5%	of "B"			$ 5,565,000	
General Conditions	10%	of "B"			$ 11,130,000	
Contractor Overhead and Profit	10%	of "B"			$ 11,130,000	
Sales Tax	9%	1/2 of "B"			$ 5,008,500	
Subtotal C Construction Costs					$ 157,500,000	
Market Factor	0%	of "C"			$ -	
Construction Costs with Market Factor					$ 157,500,000	
Change Order Contingency (10% if less than $50M)	5%	of construction costs w/Market Factor			$ 7,875,000	
Total Construction Costs					$ 165,375,000	
Planning and Permitting	5%	of total construction costs			$ 8,268,750	
Engineering	15%	of total construction costs			$ 24,806,250	
All costs presented in 2020 dollars.	15%	of total construction costs			$ 24,806,250	
Subtotal Project Costs					$ 223,300,000	
Estimating Contingency (includes market factor contingency)	30%	of subtotal Project Costs			$ 66,990,000	
Total Project Cost					$ 290,300,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 3B: Thermal Dryers				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Andritz Drum Equipment Package	$ 12,469,000 $/pkg	1 pkg	$ 12,469,000	Includes 1 dryers, drive through silos & platforms. Also includes package odor control system
Installation	$ 4,987,600 $/pkg	1 pkg	$ 4,987,600	Silos accounts for Storage
Pellet Storage for 2 Months	$ 6,900,000 LS	1 LS	$ 6,900,000	
Building for Thermal Dryer				
Excavation for Building	$ 20 $CY	2810 CY	$ 56,200	Building includes enough space to ecpand with a second unit.
Subgrade	$ 10 $CY	940 CY	$ 9,400	
Soil Disposal - Non-RCRA	$ 50 $/ton	2390 ton	$ 119,500	
Pile Foundation	$ 95 $/VLF	65,730 VLF	$ 6,244,350	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	1250 CY	$ 1,125,000	
Building Costs	$ 625 $/SF	25,280 SF	$ 15,800,000	includes space for dewatering centrifuges (4 D7LL units - 2 duty, 2 standby at annual operating conditions). Dewatering footprint (3rd floor) removed from estimate
Silo/Storage and Truck Off-Load Facility				includes dust control, instrumentation in manufacturer quote
Excavation	$ 20 $CY	645 CY	$ 12,900	
Subgrade	$ 10 $CY	215 CY	$ 2,150	
Soil Disposal - Non-RCRA	$ 50 $/ton	275 ton	$ 13,750	
Pile Foundation	$ 95 $/VLF	29,990 VLF	$ 2,849,050	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	285 CY	$ 256,500	
Miscellaneous				
18" shaftless screw conveyor 316SS, installed, no controls	$ 2,400 $/LF	800 LF	$ 1,920,000	
Controls for Screw Conveyors	$ 15,000 $/ea	1 ea	$ 15,000	
8in DI - Digested Sludge Pipeline	$ 200 $/LF	1,000 LF	$ 200,000	
Allowance for New Digested Sludge Pumps (PD Pump)	$ 1,650 $/HP (up to 50	200 hp	$ 330,000	assumes 4, 50 hp pumps
Subtotal A			$ 53,310,400	
Misc. Demolition	0% of "A"		$ -	Assumes open site - no existing building
Civil	5% of "A"		$ 2,665,520	
Yard Piping	2% of "A"		$ 1,066,208	Reduced percentage b/c DS and screw conveyors above; additional piping needed for condensate/plant drain connection
HVAC	5% of "A"		$ 2,665,520	
Shoring and Dewatering	5% of "A"		$ 2,665,520	Reduced b/c minimal below-grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 13,327,600	
Hazardous Materials and Handling	0% of "A"		$ -	assumes open site - no existing building
Misc. Excavated Soil Disposal (not deep or special excavations)	1% of "A"		$ 586,414	Allowance for miscellaneous yard piping excavation
Subtotal B			$ 76,300,000	
Startup and Construction Sequencing	12% of "B"		$ 9,156,000	
Construction Easements	5% of "B"		$ 3,815,000	
General Conditions	10% of "B"		$ 7,630,000	
Contractor Overhead and Profit	10% of "B"		$ 7,630,000	
Sales Tax	9% 1/2 of "B"		$ 3,433,500	
Subtotal C Construction Costs			$ 108,000,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 108,000,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor		$ 5,400,000	
Total Construction Costs			$ 113,400,000	
Planning and Permitting	5% of total construction costs		$ 5,670,000	
Engineering	15% of total construction costs		$ 17,010,000	
All costs presented in 2020 dollars.	15% of total construction costs		$ 17,010,000	
Subtotal Project Costs			$ 153,100,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 45,930,000	
Total Project Cost			$ 199,000,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 4: Lystek facility only				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Lystek Equipment Package (100% at 2050)	$ 2,525,000 $/pkg	4 pkg	$ 10,100,000	4 LY10s (includes KOH tank); no redundancy at 2050
Installation	$ 1,010,000 $/pkg	4 pkg	$ 4,040,000	
Lystek Facility				
Excavation	$ 20 $CY	470 CY	$ 9,400	
Subgrade	$ 10 $CY	160 CY	$ 1,600	
Soil Disposal - Non-RCRA	$ 50 $/ton	400 ton	$ 20,000	
Pile Foundation	$ 95 $/VLF	10,790 VLF	$ 1,025,050	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	210 CY	$ 189,000	
Building Costs	$ 500 $/SF	2,220 SF	$ 1,110,000	does not include dewatering
KOH Tank Slab and Containment				
Excavation	$ 20 $CY	80 CY	$ 1,600	
Subgrade	$ 10 $CY	30 CY	$ 300	
Soil Disposal - Non-RCRA	$ 50 $/ton	70 ton	$ 3,500	
Pile Foundation	$ 95 $/VLF	- VLF	$ -	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	40 CY	$ 36,000	
Concrete Walls, above-grade, 12-inch	$ 1,100 $/CY	110 CY	$ 121,000	
Odor Control for Building and Storage Tank PRVs				
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation): LS $810,000	$ 810,000 $/ea	1 ea	$ 810,000	
Stainless steel chemical storage tank: 1,7000 gallon capacity, 1 tank total	$ 46 $/gal	1,700 gallons	$ 78,710	
FRP ductwork: 300 LF of 48-inch diameter duct	$ 200 $/LF	300 lf	$ 60,000	
Miscellany				
18" shaftless screw conveyor 316SS, installed, no controls	$ 2,400 $/LF	500 LF	$ 1,200,000	
Controls for Screw Conveyors	$ 15,000 $/ea	1 ea	$ 15,000	
8in DI - Digested Sludge Pipeline	$ 200 $/LF	1,000 LF	$ 200,000	
Allowance for New Digested Sludge Pumps (PD Pump)	$ 1,650 $/HP (up to 50	200 hp	$ 330,000	assumes 4, 50 hp pumps
Subtotal A			$ 19,350,000	
Misc. Demolition	0% of "A"		$ -	assumes open site - no existing building
Civil	5% of "A"		$ 967,500	
Yard Piping	5% of "A"		$ 967,500	DS and screw conveyors above; additional piping needed for plant drain connection and other utilities. Percentage set to match thermal drying yard piping costs - facilities are similar
HVAC	5% of "A"		$ 967,500	
Shoring and Dewatering	5% of "A"		$ 967,500	Reduced b/c minimal below-grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 4,837,500	
Hazardous Materials and Handling	0% of "A"		$ -	assumes open site - no existing building
Misc. Excavated Soil Disposal (not deep or special excavations)	2.5% of "A"		$ 483,750	Allowance for miscellaneous yard piping excavation;Percentage set to match thermal drying yard piping costs - facilities are similar
Subtotal B			$ 28,540,000	
Startup and Construction Sequencing	12% of "B"		$ 3,424,800	
Construction Easements	5% of "B"		$ 1,427,000	
General Conditions	10% of "B"		$ 2,854,000	
Contractor Overhead and Profit	10% of "B"		$ 2,854,000	
Sales Tax	9% 1/2 of "B"		$ 1,284,300	
Subtotal C Construction Costs			$ 40,400,000	
Market Factor	0% of "C"		$ -	
All costs presented in 2020 dollars.				
Construction Costs with Market Factor			$ 40,400,000	
Change Order Contingency (10% if less than $50M)	10% of construction costs w/Market Factor		$ 4,040,000	Increase to 10% b/c costs are less than $50M
Total Construction Costs			$ 44,440,000	
Planning and Permitting	5% of total construction costs		$ 2,222,000	
Engineering	15% of total construction costs		$ 6,666,000	
Construction Management	15% of total construction costs		$ 6,666,000	
Subtotal Project Costs			$ 60,000,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 18,000,000	
Total Project Cost			$ 78,000,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 4: Lystek Storage only (3 months)				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Lystek Storage				Assumes odor control for PRVs is with building odor control system
Round concrete tank 100 ft diam, 10ft below grade	$ 6 $/gal	16,200,000 gallons	$ 97,200,000	$6/gal is based on USD
Excavation	$ - $CY	30,252 CY	$ -	This is accounted for in the over excavation per gal price
Subgrade	$ - $CY	2,327 CY	$ -	This is accounted for in the over excavation per gal price
Soil Disposal - Non-RCRA	$ 50 $/ton	25,720 ton	$ 1,286,000	
Pile Foundation	$ - $/VLF	163,370 VLF	$ -	This is accounted for in the over excavation per gal price
Subtotal A			$ 98,486,000	
Misc. Demolition	5% of "A"			
Civil	5% of "A"			
Yard Piping	12% of "A"			
HVAC	5% of "A"			
Shoring and Dewatering	10% of "A"			
Electrical, Instrumentation & Controls	25% of "A"			
Hazardous Materials and Handling	5% of "A"			
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"			
Subtotal B			$ 98,500,000	
Startup and Construction Sequencing	12% of "B"			
Construction Easements	5% of "B"			
General Conditions	10% of "B"			
Contractor Overhead and Profit	10% of "B"			
Sales Tax	9% 1/2 of "B"			
Subtotal C Construction Costs			$ 98,500,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 98,500,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor			
Total Construction Costs			$ 98,500,000	
Planning and Permitting	5% of total construction costs		$ 4,925,000	
Engineering	15% of total construction costs		$ 14,775,000	
Construction Management	15% of total construction costs		$ 14,775,000	
Subtotal Project Costs			$ 133,000,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 39,900,000	
Total Project Cost			$ 172,900,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 4: Lystek Storage only (1 month)				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
Lystek Storage				Assumes odor control for PRVs is with building odor control system
Round concrete tank 100 ft diam, 10ft below grade	$ 6 $/gal	5,400,000 gallons	$ 32,400,000	$6/gal is based on USD
Excavation	$ - $CY	11,345 CY	$ -	This is accounted for in the over excavation per gal price
Subgrade	$ - $CY	873 CY	$ -	This is accounted for in the over excavation per gal price
Soil Disposal - Non-RCRA	$ 50 $/ton	9,650 ton	$ 482,500	
Pile Foundation	$ - $/VLF	61,270 VLF	$ -	This is accounted for in the over excavation per gal price
Subtotal A			$ 32,882,500	
Misc. Demolition	5% of "A"			
Civil	5% of "A"			
Yard Piping	12% of "A"			
HVAC	5% of "A"			
Shoring and Dewatering	10% of "A"			
Electrical, Instrumentation & Controls	25% of "A"			
Hazardous Materials and Handling	5% of "A"			
Misc. Excavated Soil Disposal (not deep or special excavations)	5% of "A"			
Subtotal B			$ 32,900,000	
Startup and Construction Sequencing	12% of "B"			
Construction Easements	5% of "B"			
General Conditions	10% of "B"			
Contractor Overhead and Profit	10% of "B"			
Sales Tax	9% 1/2 of "B"			
Subtotal C Construction Costs			$ 32,900,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 32,900,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor			
Total Construction Costs			$ 32,900,000	
Planning and Permitting	5% of total construction costs		$ 1,645,000	
Engineering	15% of total construction costs		$ 4,935,000	
Construction Management	15% of total construction costs		$ 4,935,000	
Subtotal Project Costs			$ 44,400,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 13,320,000	
Total Project Cost			$ 57,700,000	

All costs presented in 2020 dollars.
All costs are rounded.

Alternative 5: Pyrolysis				
Item	**Unit Cost**	**Units**	**Class V Total**	**Notes**
BioforceTech Equipment Package	$ 6,900,000 $/pkg	4 pkg	$ 27,600,000	This doesn't account for Redundancy (need a 5th one for redundancy); includes equipment and biodryer
Installation	$ 2,760,000 $/pkg	4 pkg	$ 11,040,000	includes dried biosolids storage; no other storage included
Pyrolysis Building				
Excavation	$ 20 $CY	8000 CY	$ 160,000	
Subgrade	$ 10 $CY	2670 CY	$ 26,700	
Soil Disposal - Non-RCRA	$ 50 $/ton	6800 ton	$ 340,000	
Pile Foundation	$ 95 $/VLF	187,200 VLF	$ 17,784,000	
Concrete Slab, at grade, 16-inch	$ 900 $/CY	3560 CY	$ 3,204,000	
Building Costs	$ 450 $/SF	72,000 SF	$ 32,400,000	footprint provided for bagged dried product
Odor Control for Building				
Chemical scrubbers (includes fans, chemical metering and recirculation pumps, and instrumentation): LS $810,000	$ 810,000 $/ea	1 ea	$ 810,000	
Stainless steel chemical storage tank: 1,7000 gallon capacity, 1 tank total	$ 46 $/gal	1,700 gallons	$ 78,710	
FRP ductwork: 300 LF of 48-inch diameter duct	$ 200 $/LF	300 lf	$ 60,000	
Miscellaneous				
18" shaftless screw conveyor 316SS, installed, no controls	$ 2,400 $/LF	800 LF	$ 1,920,000	
Controls for Screw Conveyors	$ 15,000 $/ea	1 ea	$ 15,000	
8in DI Digested Sludge Pipeline	$ 200 $/LF	1,000 LF	$ 200,000	
Allowance for New Digested Sludge Pumps (PD Pumps)	$ 1,650 $/HP (up to 50	200 hp	$ 330,000	assumes 4, 50 hp pumps
Subtotal A			$ 95,968,410	
Misc. Demolition	0% of "A"		$ -	Reduced b/c assume on open site so minimal demolition required
Civil	5% of "A"		$ 4,798,421	
Yard Piping	1% of "A"		$ 959,684	Reduced percentage b/c DS and screw conveyors above; additional piping needed for plant drain connection and other utilities; Percentage set to match thermal drying yard piping costs - facilities are similar
HVAC	5% of "A"		$ 4,798,421	
Shoring and Dewatering	5% of "A"		$ 4,798,421	Reduced b/c minimal below-grade construction
Electrical, Instrumentation & Controls	25% of "A"		$ 23,992,103	
Hazardous Materials and Handling	0% of "A"		$ -	Eliminated b/c new building - no reuse of existing facilities
Misc. Excavated Soil Disposal (not deep or special excavations)	1% of "A"		$ 479,842	Allowance for miscellaneous yard piping excavation; Percentage set to match thermal drying yard piping costs - facilities are similar
Subtotal B			$ 135,800,000	
Startup and Construction Sequencing	12% of "B"		$ 16,296,000	
Construction Easements	5% of "B"		$ 6,790,000	
General Conditions	10% of "B"		$ 13,580,000	
Contractor Overhead and Profit	10% of "B"		$ 13,580,000	
Sales Tax	9% 1/2 of "B"		$ 6,111,000	
Subtotal C Construction Costs			$ 192,200,000	
Market Factor	0% of "C"		$ -	
Construction Costs with Market Factor			$ 192,200,000	
Change Order Contingency (10% if less than $50M)	5% of construction costs w/Market Factor		$ 9,610,000	
Total Construction Costs			$ 201,810,000	
Planning and Permitting	5% of total construction costs		$ 10,090,500	
Engineering	15% of total construction costs		$ 30,271,500	
All costs presented in 2020 dollars.	15% of total construction costs		$ 30,271,500	
Subtotal Project Costs			$ 272,400,000	
Estimating Contingency (includes market factor contingency)	30% of subtotal Project Costs		$ 81,720,000	
Total Project Cost			$ 354,100,000	

All costs presented in 2020 dollars.
All costs are rounded.

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Net Present Values

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From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 0 - Status Quo

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,235,137	4,358,315	6,358,311	6,722,311	7,149,652	7,414,562	7,688,250	7,970,988	8,263,057	8,564,748	8,876,359	9,198,198	9,530,581	9,873,835	10,228,294
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Labor	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880
Total running costs	**5,711,945**	**5,851,458**	**7,867,789**	**8,248,125**	**8,691,801**	**8,973,047**	**9,263,070**	**9,562,143**	**9,870,548**	**10,188,575**	**10,516,521**	**10,854,696**	**11,203,414**	**11,563,003**	**11,933,798**
R&R Costs:															
Screening															
2nd Stage Digester Rehab															
Total refurbishments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Net Benefit/(cost)	**(3,488,909)**	**(3,610,962)**	**(5,609,833)**	**(5,972,709)**	**(6,441,603)**	**(6,757,213)**	**(7,081,600)**	**(7,415,037)**	**(7,757,806)**	**(8,111,890)**	**(8,475,894)**	**(8,850,126)**	**(9,234,902)**	**(9,630,548)**	**(9,475,464)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,235,137	4,358,315	6,358,311	6,722,311	7,149,652	7,414,562	7,688,250	7,970,988	8,263,057	8,564,748	8,876,359	9,198,198	9,530,581	9,873,835	10,228,294
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Labor	152,880	157,466	162,190	167,056	172,068	177,230	182,547	188,023	193,664	199,474	205,458	211,622	217,970	224,509	231,245
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**5,711,945**	**5,896,252**	**7,959,717**	**8,389,609**	**8,885,355**	**9,221,273**	**9,568,668**	**9,927,908**	**10,299,379**	**10,683,473**	**11,080,600**	**11,491,178**	**11,915,641**	**12,354,435**	**12,808,021**
R&R Costs:															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2nd Stage Digester Rehab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Net escalated benefit/(cost)	**(3,488,909)**	**(3,588,542)**	**(5,564,251)**	**(5,903,200)**	**(6,352,737)**	**(6,652,515)**	**(6,963,878)**	**(7,287,239)**	**(7,623,020)**	**(7,973,871)**	**(8,338,168)**	**(8,716,385)**	**(9,109,013)**	**(9,516,560)**	**(9,089,571)**
Life cycle cost analysis															
PVs in 2021	(3,488,909)	(3,518,178)	(5,348,185)	(5,562,717)	(5,868,947)	(6,025,387)	(6,183,725)	(6,343,980)	(6,506,174)	(6,672,179)	(6,840,202)	(7,010,266)	(7,182,395)	(7,356,611)	(6,888,759)
NPV as of 2021	**(208,882,204)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
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	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Screening															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	10,594,305	10,972,224	11,362,418	11,765,264	12,181,150	12,610,477	13,053,658	13,511,116	13,983,289	14,470,625	14,973,589	15,492,657	16,028,320	16,581,083	17,151,467
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Labor	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880	152,880
Total running costs	12,316,144	12,710,399	13,116,928	13,536,109	13,968,330	14,413,993	14,873,509	15,347,303	15,835,811	16,339,483	16,858,782	17,394,185	17,946,184	18,515,282	19,102,001
R&R Costs:															
Screening															
2nd Stage Digester Rehab															
Total refurbishments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Benefit/(cost)	(9,842,044)	(10,220,532)	(10,611,294)	(11,014,709)	(11,430,656)	(11,860,552)	(12,304,301)	(12,762,328)	(13,235,069)	(13,722,975)	(14,262,073)	(14,833,534)	(15,421,589)	(15,992,427)	(16,580,884)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	10,594,305	10,972,224	11,362,418	11,765,264	12,181,150	12,610,477	13,053,658	13,511,116	13,983,289	14,470,625	14,973,589	15,492,657	16,028,320	16,581,083	17,151,467
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Labor	238,182	245,328	252,687	260,268	268,076	276,118	284,402	292,934	301,722	310,774	320,097	329,700	339,591	349,778	360,272
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	13,276,874	13,761,484	14,262,355	14,780,009	15,314,982	15,867,828	16,439,118	17,029,440	17,639,401	18,269,628	18,920,764	19,593,476	20,288,449	21,006,391	21,748,029
R&R Costs:															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2nd Stage Digester Rehab	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net escalated benefit/(cost)	(9,422,307)	(9,765,978)	(10,120,925)	(10,487,494)	(10,865,154)	(11,256,028)	(11,659,634)	(12,076,361)	(12,506,613)	(12,950,805)	(13,483,832)	(14,071,197)	(14,680,596)	(15,234,280)	(15,806,852)
Life cycle cost analysis															
PVs in 2021	(7,000,913)	(7,113,986)	(7,227,986)	(7,342,917)	(7,458,176)	(7,574,984)	(7,692,744)	(7,811,461)	(7,931,143)	(8,051,794)	(8,218,812)	(8,408,656)	(8,600,804)	(8,750,183)	(8,901,033)
NPV as of 2021	(208,882,204)														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
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From Summary Sheet:		**Risk adjustments (+/- percent):**	
Year of analysis	**2021**	**Benefits**	**0%**
Escalation rate	**3.00%**	**Capital costs**	**0%**
Discount rate	**2.00%**	**Running costs**	**0%**

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Pinole	80,500,000														
Front Loader	170,000														
Total capital outlays	**96,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
Biosolids Disposition	4,235,137	4,508,281	4,658,644	4,816,353	5,048,690	5,235,755	5,429,018	5,628,672	5,834,915	6,047,953	6,267,996	6,495,260	6,729,971	6,972,358	7,222,657
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**6,654,045**	**6,943,524**	**7,110,222**	**7,284,267**	**7,532,939**	**7,736,340**	**7,945,938**	**8,161,928**	**8,384,506**	**8,613,879**	**8,850,257**	**9,093,858**	**9,344,904**	**9,603,626**	**9,870,261**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site		40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Total refurbishments	**0**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**
Net Benefit/(cost)	**(100,701,009)**	**(5,055,028)**	**(5,204,266)**	**(5,360,850)**	**(5,634,742)**	**(5,872,506)**	**(6,116,468)**	**(6,366,822)**	**(6,623,764)**	**(6,889,195)**	**(7,161,630)**	**(7,441,288)**	**(7,728,392)**	**(8,023,171)**	**(7,763,927)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	80,500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**96,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,235,137	4,508,281	4,658,644	4,816,353	5,048,690	5,235,755	5,429,018	5,628,672	5,834,915	6,047,953	6,267,996	6,495,260	6,729,971	6,972,358	7,222,657
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	1,070,160	1,102,265	1,135,333	1,169,393	1,204,475	1,240,609	1,277,827	1,316,162	1,355,647	1,396,316	1,438,206	1,481,352	1,525,792	1,571,566	1,618,713
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	24,820	25,565	26,332	27,121	27,935	28,773	29,636	30,525	31,441	32,384	33,356	34,357	35,387	36,449	37,542
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**6,654,045**	**7,016,582**	**7,259,524**	**7,513,109**	**7,844,735**	**8,134,618**	**8,434,353**	**8,744,257**	**9,064,661**	**9,395,905**	**9,738,340**	**10,092,327**	**10,458,240**	**10,836,464**	**11,227,395**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
Pinole site	0	41,200	42,436	43,709	45,020	46,371	47,762	49,195	50,671	52,191	53,757	55,369	57,030	58,741	60,504
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**362,560**	**373,437**	**384,640**	**396,179**	**408,064**	**420,306**	**432,916**	**445,903**	**459,280**	**473,059**	**487,250**	**501,868**	**516,924**	**532,432**
Net escalated benefit/(cost)	**(100,701,009)**	**(5,071,431)**	**(5,237,495)**	**(5,411,340)**	**(5,708,296)**	**(5,973,924)**	**(6,249,870)**	**(6,536,503)**	**(6,834,206)**	**(7,145,583)**	**(7,468,966)**	**(7,804,784)**	**(8,153,480)**	**(8,515,513)**	**(8,041,377)**
Life cycle cost analysis															
PVs in 2021	(100,701,009)	(4,971,991)	(5,034,117)	(5,099,227)	(5,273,583)	(5,410,767)	(5,549,705)	(5,690,419)	(5,832,929)	(5,979,104)	(6,127,154)	(6,277,099)	(6,428,963)	(6,582,768)	(6,094,359)
NPV as of 2021	**(284,755,981)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

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	Year														
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Pinole															
Front Loader															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
Biosolids Disposition	7,481,114	7,747,980	8,023,513	8,307,980	8,601,656	8,904,824	9,217,774	9,540,805	9,874,227	10,218,358	10,573,523	10,940,060	11,318,316	11,708,647	12,292,569
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**10,145,053**	**10,428,254**	**10,720,123**	**11,020,926**	**11,330,937**	**11,650,440**	**11,979,725**	**12,319,092**	**12,668,849**	**13,029,315**	**13,400,816**	**13,783,688**	**14,178,279**	**14,584,946**	**15,185,203**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Total refurbishments	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**
Net Benefit/(cost)	**(8,022,953)**	**(8,290,387)**	**(8,566,489)**	**(8,851,525)**	**(9,145,262)**	**(9,448,998)**	**(9,762,517)**	**(10,086,117)**	**(10,420,108)**	**(10,764,807)**	**(11,156,107)**	**(11,575,037)**	**(12,005,685)**	**(12,414,090)**	**(13,016,086)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,481,114	7,747,980	8,023,513	8,307,980	8,601,656	8,904,824	9,217,774	9,540,805	9,874,227	10,218,358	10,573,523	10,940,060	11,318,316	11,708,647	12,292,569
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	1,667,274	1,717,293	1,768,811	1,821,876	1,876,532	1,932,828	1,990,813	2,050,537	2,112,053	2,175,415	2,240,677	2,307,898	2,377,135	2,448,449	2,521,902
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	38,669	39,829	41,024	42,254	43,522	44,828	46,173	47,558	48,984	50,454	51,968	53,527	55,132	56,786	58,490
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**11,631,444**	**12,049,033**	**12,480,598**	**12,926,588**	**13,387,466**	**13,863,712**	**14,355,817**	**14,864,290**	**15,389,656**	**15,932,456**	**16,493,247**	**17,072,604**	**17,671,122**	**18,289,411**	**19,109,251**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
Pinole site	62,319	64,188	66,114	68,097	70,140	72,244	74,412	76,644	78,943	81,312	83,751	86,264	88,852	91,517	94,263
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**548,405**	**564,857**	**581,802**	**599,256**	**617,234**	**635,751**	**654,824**	**674,468**	**694,702**	**715,544**	**737,010**	**759,120**	**781,894**	**805,351**	**829,511**
Net escalated benefit/(cost)	**(8,325,281)**	**(8,618,385)**	**(8,920,970)**	**(9,233,329)**	**(9,554,872)**	**(9,887,663)**	**(10,231,156)**	**(10,585,679)**	**(10,951,570)**	**(11,329,177)**	**(11,793,324)**	**(12,309,445)**	**(12,845,162)**	**(13,322,651)**	**(13,997,586)**
Life cycle cost analysis															
PVs in 2021	(6,185,807)	(6,278,026)	(6,371,023)	(6,464,802)	(6,558,758)	(6,654,114)	(6,750,269)	(6,847,231)	(6,945,003)	(7,043,593)	(7,188,395)	(7,355,870)	(7,525,493)	(7,652,191)	(7,882,213)
NPV as of 2021	**(284,755,981)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 1 - Merchant Facilities (100%)

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Total capital outlays	**15,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Other															
Other															
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,106,474	8,698,886	9,333,205	10,012,326	10,739,341	11,137,258	11,548,358	11,973,052	12,411,764	12,864,927	13,332,992	13,816,419	14,315,685	14,831,279	15,363,705
Chemicals	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Natural gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**9,430,402**	**10,039,150**	**10,689,804**	**11,385,260**	**12,128,611**	**12,542,862**	**12,970,298**	**13,411,328**	**13,866,375**	**14,335,874**	**14,820,274**	**15,320,037**	**15,835,638**	**16,367,567**	**16,916,328**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**
Net Benefit/(cost)	**(22,807,367)**	**(8,110,654)**	**(8,743,848)**	**(9,421,843)**	**(10,190,413)**	**(10,639,029)**	**(11,100,828)**	**(11,576,222)**	**(12,065,633)**	**(12,571,189)**	**(13,091,647)**	**(13,627,467)**	**(14,179,126)**	**(14,747,112)**	**(14,769,995)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**15,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,106,474	8,698,886	9,333,205	10,012,326	10,739,341	11,137,258	11,548,358	11,973,052	12,411,764	12,864,927	13,332,992	13,816,419	14,315,685	14,831,279	15,363,705
Chemicals	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Natural gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**9,430,402**	**10,079,358**	**10,772,420**	**11,512,568**	**12,302,976**	**12,766,739**	**13,246,229**	**13,741,950**	**14,254,421**	**14,784,179**	**15,331,775**	**15,897,777**	**16,482,774**	**17,087,370**	**17,712,187**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**321,360**	**331,001**	**340,931**	**351,159**	**361,694**	**372,544**	**383,721**	**395,232**	**407,089**	**419,302**	**431,881**	**444,837**	**458,183**	**471,928**
Net escalated benefit/(cost)	**(22,807,367)**	**(8,093,007)**	**(8,707,956)**	**(9,367,090)**	**(10,121,517)**	**(10,559,674)**	**(11,013,984)**	**(11,485,001)**	**(11,973,295)**	**(12,481,666)**	**(13,008,644)**	**(13,554,865)**	**(14,120,984)**	**(14,707,677)**	**(14,465,665)**
Life cycle cost analysis															
PVs in 2021	(22,807,367)	(7,934,321)	(8,369,815)	(8,826,818)	(9,350,718)	(9,564,222)	(9,780,103)	(9,998,384)	(10,219,092)	(10,444,100)	(10,671,619)	(10,901,677)	(11,134,300)	(11,369,513)	(10,963,166)
NPV as of 2021	**(349,273,568)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 1 - Merchant Facilities (100%)

Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)

Year	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Other															
Other															
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	15,913,482	16,481,147	17,067,248	17,672,354	18,297,048	18,941,932	19,607,624	20,294,762	21,004,003	21,736,021	22,491,512	23,271,193	24,075,801	24,906,095	25,762,856
Chemicals	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Natural gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**17,482,441**	**18,066,441**	**18,668,878**	**19,290,319**	**19,931,349**	**20,592,568**	**21,274,596**	**21,978,069**	**22,703,645**	**23,451,998**	**24,223,825**	**25,019,842**	**25,840,785**	**26,687,414**	**27,560,510**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**	**312,000**
Net Benefit/(cost)	**(15,320,341)**	**(15,888,574)**	**(16,475,244)**	**(17,080,919)**	**(17,705,674)**	**(18,351,126)**	**(19,017,387)**	**(19,705,094)**	**(20,414,903)**	**(21,147,490)**	**(21,939,116)**	**(22,771,190)**	**(23,628,191)**	**(24,476,559)**	**(25,351,394)**

Expressed in escalated dollars with sensitivity adjustments

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	15,913,482	16,481,147	17,067,248	17,672,354	18,297,048	18,941,932	19,607,624	20,294,762	21,004,003	21,736,021	22,491,512	23,271,193	24,075,801	24,906,095	25,762,856
Chemicals	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Natural gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**18,357,869**	**19,025,079**	**19,714,498**	**20,426,831**	**21,162,804**	**21,923,164**	**22,708,682**	**23,520,152**	**24,358,393**	**25,224,250**	**26,118,591**	**27,042,313**	**27,996,340**	**28,981,624**	**29,999,147**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**486,086**	**500,668**	**515,688**	**531,159**	**547,094**	**563,507**	**580,412**	**597,824**	**615,759**	**634,232**	**653,259**	**672,856**	**693,042**	**713,833**	**735,248**
Net escalated benefit/(cost)	**(14,989,388)**	**(15,530,242)**	**(16,088,756)**	**(16,665,476)**	**(17,260,070)**	**(17,874,871)**	**(18,509,610)**	**(19,164,897)**	**(19,841,364)**	**(20,539,659)**	**(21,334,917)**	**(22,192,890)**	**(23,081,529)**	**(23,923,347)**	**(24,793,218)**

Life cycle cost analysis

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PVs in 2021	(11,137,336)	(11,312,940)	(11,489,987)	(11,668,489)	(11,847,843)	(12,029,276)	(12,212,193)	(12,396,604)	(12,582,518)	(12,769,947)	(13,004,291)	(13,262,012)	(13,522,592)	(13,740,962)	(13,961,366)
NPV as of 2021	**(349,273,568)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 2 - Thermal Hydrolysis (No Storage)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
THP w/o storage	600,200,000														
Total capital outlays	**600,200,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,144,222	2,162,190	2,180,666	2,198,635	2,120,068	2,085,704	2,051,340	2,016,976	1,982,612	1,946,555	1,910,497	1,874,440	1,838,382	1,802,325	2,388,157
Digester Phase 4 Seismic Upgrades	13,100,000														
Total benefits	**15,244,222**	**2,162,190**	**2,180,666**	**2,198,635**	**2,120,068**	**2,085,704**	**2,051,340**	**2,016,976**	**1,982,612**	**1,946,555**	**1,910,497**	**1,874,440**	**1,838,382**	**1,802,325**	**2,388,157**
Annual Running Costs:															
Biosolids Disposition	4,000,464	4,487,382	4,740,302	5,009,846	5,297,159	5,634,431	5,843,736	6,059,984	6,283,392	6,514,183	6,752,587	6,998,839	7,253,184	7,515,872	7,787,160
Natural Gas	1,840,755	1,862,225	1,883,695	1,905,166	1,717,988	1,626,112	1,534,236	1,442,361	1,350,485	1,258,609	1,166,734	1,074,858	982,982	891,107	2,141,339
Chemicals	2,926,997	2,962,014	2,997,030	3,032,047	3,067,064	3,102,080	3,137,097	3,172,114	3,207,130	3,242,147	3,277,164	3,312,181	3,347,197	3,382,214	3,417,231
Labor	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560
Total running costs	**10,602,776**	**11,146,181**	**11,455,588**	**11,781,618**	**11,916,770**	**12,197,184**	**12,349,629**	**12,509,018**	**12,675,568**	**12,849,500**	**13,031,044**	**13,220,438**	**13,417,923**	**13,623,752**	**15,180,290**
R&R Costs:															
R&R		2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419
Total refurbishments	**0**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**
Net Benefit/(cost)	**(595,558,554)**	**(11,590,410)**	**(11,881,340)**	**(12,189,403)**	**(12,403,121)**	**(12,717,899)**	**(12,904,708)**	**(13,098,462)**	**(13,299,375)**	**(13,509,364)**	**(13,726,966)**	**(13,952,417)**	**(14,185,960)**	**(14,427,847)**	**(15,398,552)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
THP w/o storage	600,200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**600,200,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,144,222	2,227,056	2,313,469	2,402,508	2,386,155	2,417,903	2,449,407	2,480,626	2,511,514	2,539,812	2,567,549	2,594,663	2,621,093	2,646,775	3,612,302
Digester Phase 4 Seismic Upgrades	13,100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**15,244,222**	**2,227,056**	**2,313,469**	**2,402,508**	**2,386,155**	**2,417,903**	**2,449,407**	**2,480,626**	**2,511,514**	**2,539,812**	**2,567,549**	**2,594,663**	**2,621,093**	**2,646,775**	**3,612,302**
Annual Running Costs:															
Biosolids Disposition	4,000,464	4,487,382	4,740,302	5,009,846	5,297,159	5,634,431	5,843,736	6,059,984	6,283,392	6,514,183	6,752,587	6,998,839	7,253,184	7,515,872	7,787,160
Natural Gas	1,840,755	1,918,092	1,998,412	2,081,826	1,933,610	1,885,109	1,831,958	1,773,922	1,710,754	1,642,200	1,567,992	1,487,855	1,401,498	1,308,620	3,238,967
Chemicals	2,926,997	3,050,874	3,179,550	3,313,200	3,452,007	3,596,161	3,745,858	3,901,300	4,062,697	4,230,267	4,404,234	4,584,832	4,772,303	4,966,895	5,168,868
Labor	1,834,560	1,889,597	1,946,285	2,004,673	2,064,813	2,126,758	2,190,561	2,256,277	2,323,966	2,393,685	2,465,495	2,539,460	2,615,644	2,694,113	2,774,937
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**10,602,776**	**11,345,945**	**11,864,548**	**12,409,545**	**12,747,590**	**13,242,460**	**13,612,113**	**13,991,483**	**14,380,809**	**14,780,334**	**15,190,309**	**15,610,986**	**16,042,628**	**16,485,500**	**18,969,932**
R&R Costs:															
R&R	0	2,684,612	2,765,150	2,848,105	2,933,548	3,021,554	3,112,201	3,205,567	3,301,734	3,400,786	3,502,810	3,607,894	3,716,131	3,827,615	3,942,443
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**2,684,612**	**2,765,150**	**2,848,105**	**2,933,548**	**3,021,554**	**3,112,201**	**3,205,567**	**3,301,734**	**3,400,786**	**3,502,810**	**3,607,894**	**3,716,131**	**3,827,615**	**3,942,443**
Net escalated benefit/(cost)	**(595,558,554)**	**(11,803,501)**	**(12,316,230)**	**(12,855,142)**	**(13,294,982)**	**(13,846,112)**	**(14,274,906)**	**(14,716,424)**	**(15,171,029)**	**(15,641,308)**	**(16,125,570)**	**(16,624,218)**	**(17,137,666)**	**(17,666,340)**	**(19,300,073)**
Life cycle cost analysis															
PVs in 2021	(595,558,554)	(11,572,060)	(11,837,975)	(12,113,687)	(12,282,509)	(12,540,850)	(12,675,708)	(12,811,532)	(12,948,327)	(13,087,947)	(13,228,584)	(13,370,244)	(13,512,932)	(13,656,655)	(14,627,043)
NPV as of 2021	**(1,021,896,700)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 2 - Thermal Hydrolysis (No Storage)

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
THP w/o storage															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,404,940	2,421,215	2,437,997	2,454,272	2,470,547	2,487,330	2,503,604	2,520,387	2,536,662	2,552,937	2,466,579	2,430,522	2,394,464	2,389,819	2,385,173
Digester Phase 4 Seismic Upgrades															
Total benefits	**2,404,940**	**2,421,215**	**2,437,997**	**2,454,272**	**2,470,547**	**2,487,330**	**2,503,604**	**2,520,387**	**2,536,662**	**2,552,937**	**2,466,579**	**2,430,522**	**2,394,464**	**2,389,819**	**2,385,173**
Annual Running Costs:															
Biosolids Disposition	8,067,316	8,356,613	8,655,332	8,963,764	9,282,209	9,610,973	9,950,374	10,300,739	10,662,402	11,035,711	11,421,021	11,818,700	12,229,124	12,652,683	13,089,776
Natural Gas	2,162,809	2,184,279	2,205,750	2,227,220	2,248,690	2,270,161	2,291,631	2,313,101	2,334,571	2,356,042	2,154,906	2,063,030	1,971,155	1,879,279	1,787,403
Chemicals	3,452,247	3,487,264	3,522,281	3,557,297	3,592,314	3,627,331	3,662,347	3,697,364	3,732,381	3,767,397	3,802,414	3,837,431	3,872,447	3,907,464	3,942,481
Labor	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560	1,834,560
Total running costs	**15,516,932**	**15,862,716**	**16,217,922**	**16,582,842**	**16,957,773**	**17,343,024**	**17,738,912**	**18,145,764**	**18,563,914**	**18,993,710**	**19,212,902**	**19,553,721**	**19,907,286**	**20,273,986**	**20,654,220**
R&R Costs:															
R&R	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419	2,606,419
Total refurbishments	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**	**2,606,419**
Net Benefit/(cost)	**(15,718,412)**	**(16,047,921)**	**(16,386,344)**	**(16,734,989)**	**(17,093,645)**	**(17,462,114)**	**(17,841,727)**	**(18,231,796)**	**(18,633,672)**	**(19,047,193)**	**(19,352,742)**	**(19,729,619)**	**(20,119,241)**	**(20,490,587)**	**(20,875,467)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
THP w/o storage	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,746,818	3,885,339	4,029,638	4,178,234	4,332,119	4,492,394	4,657,442	4,829,323	5,006,322	5,189,595	5,164,469	5,241,642	5,318,797	5,467,732	5,620,816
Digester Phase 4 Seismic Upgrades	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,746,818**	**3,885,339**	**4,029,638**	**4,178,234**	**4,332,119**	**4,492,394**	**4,657,442**	**4,829,323**	**5,006,322**	**5,189,595**	**5,164,469**	**5,241,642**	**5,318,797**	**5,467,732**	**5,620,816**
Annual Running Costs:															
Biosolids Disposition	8,067,316	8,356,613	8,655,332	8,963,764	9,282,209	9,610,973	9,950,374	10,300,739	10,662,402	11,035,711	11,421,021	11,818,700	12,229,124	12,652,683	13,089,776
Natural Gas	3,369,586	3,505,127	3,645,768	3,791,693	3,943,092	4,100,162	4,263,108	4,432,141	4,607,479	4,789,348	4,511,895	4,449,114	4,378,505	4,299,655	4,212,133
Chemicals	5,378,489	5,596,035	5,821,793	6,056,060	6,299,144	6,551,363	6,813,045	7,084,532	7,366,176	7,658,343	7,961,410	8,275,769	8,601,825	8,939,995	9,290,714
Labor	2,858,185	2,943,930	3,032,248	3,123,216	3,216,912	3,313,419	3,412,822	3,515,207	3,620,663	3,729,283	3,841,161	3,956,396	4,075,088	4,197,341	4,323,261
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**19,673,576**	**20,401,705**	**21,155,141**	**21,934,733**	**22,741,357**	**23,575,918**	**24,439,349**	**25,332,618**	**26,256,720**	**27,212,685**	**27,735,488**	**28,499,979**	**29,284,541**	**30,089,673**	**30,915,884**
R&R Costs:															
R&R	4,060,716	4,182,538	4,308,014	4,437,254	4,570,372	4,707,483	4,848,708	4,994,169	5,143,994	5,298,314	5,457,263	5,620,981	5,789,611	5,963,299	6,142,198
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**4,060,716**	**4,182,538**	**4,308,014**	**4,437,254**	**4,570,372**	**4,707,483**	**4,848,708**	**4,994,169**	**5,143,994**	**5,298,314**	**5,457,263**	**5,620,981**	**5,789,611**	**5,963,299**	**6,142,198**
Net escalated benefit/(cost)	**(19,987,474)**	**(20,698,904)**	**(21,433,517)**	**(22,193,754)**	**(22,979,610)**	**(23,791,007)**	**(24,630,616)**	**(25,497,464)**	**(26,394,392)**	**(27,321,404)**	**(28,028,282)**	**(28,879,318)**	**(29,755,355)**	**(30,585,240)**	**(31,437,266)**
Life cycle cost analysis															
PVs in 2021	(14,850,988)	(15,078,030)	(15,307,015)	(15,539,165)	(15,773,911)	(16,010,666)	(16,250,684)	(16,492,755)	(16,738,160)	(16,986,304)	(17,084,103)	(17,257,682)	(17,432,533)	(17,567,384)	(17,702,712)
NPV as of 2021	**(1,021,896,700)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 3A - Thermal Drying

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	290,300,000														
Screening	15,600,000														
Total capital outlays	**305,900,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	78,510	79,479	80,448	81,417	82,385	83,354	84,323	85,291	86,260	87,229	88,197	89,166	90,135	91,104	92,072
Energy Offset	1,892,784	1,910,244	1,927,704	1,945,164	1,919,946	1,885,582	1,851,218	1,816,854	1,782,490	1,746,433	1,710,375	1,674,318	1,638,260	1,602,203	2,128,082
Total benefits	**1,971,294**	**1,989,723**	**2,008,152**	**2,026,581**	**2,002,331**	**1,968,936**	**1,935,541**	**1,902,145**	**1,868,750**	**1,833,661**	**1,798,573**	**1,763,484**	**1,728,395**	**1,693,306**	**2,220,154**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	556,239	564,447	572,688	580,961	602,570	624,897	647,963	671,792	696,408	721,834	748,097	775,221	803,235	832,164	862,038
Natural Gas	2,235,501	2,263,084	2,290,667	2,318,250	2,253,279	2,168,893	2,084,507	2,000,120	1,915,734	1,831,348	1,746,961	1,662,575	1,578,189	1,493,802	2,621,663
Chemicals	1,393,523	1,409,926	1,426,329	1,442,732	1,459,135	1,475,538	1,491,941	1,508,344	1,524,746	1,541,149	1,557,552	1,573,955	1,590,358	1,606,761	1,623,164
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs	**5,714,063**	**5,766,257**	**5,818,484**	**5,870,743**	**5,843,785**	**5,798,128**	**5,753,211**	**5,709,056**	**5,665,688**	**5,623,131**	**5,581,411**	**5,540,552**	**5,500,581**	**5,461,527**	**6,635,664**
R&R Costs:															
R&R		498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**
Net Benefit/(cost)	**(309,642,769)**	**(4,587,294)**	**(4,621,092)**	**(4,654,922)**	**(4,652,214)**	**(4,639,952)**	**(4,628,430)**	**(4,617,671)**	**(4,607,698)**	**(4,600,230)**	**(4,593,598)**	**(4,587,828)**	**(4,582,946)**	**(4,578,981)**	**(5,226,271)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	290,300,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**305,900,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	78,510	81,863	85,347	88,966	92,725	96,630	100,686	104,898	109,272	113,814	118,530	123,427	128,511	133,789	139,268
Energy Offset	1,892,784	1,967,551	2,045,101	2,125,534	2,160,916	2,185,906	2,210,451	2,234,501	2,258,005	2,278,698	2,298,601	2,317,647	2,335,767	2,352,889	3,218,914
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**1,971,294**	**2,049,415**	**2,130,448**	**2,214,500**	**2,253,641**	**2,282,536**	**2,311,137**	**2,339,399**	**2,367,277**	**2,392,512**	**2,417,131**	**2,441,074**	**2,464,278**	**2,486,677**	**3,358,182**
Annual Running Costs:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	556,239	564,447	572,688	580,961	602,570	624,897	647,963	671,792	696,408	721,834	748,097	775,221	803,235	832,164	862,038
Natural Gas	2,235,501	2,330,977	2,430,169	2,533,215	2,536,086	2,514,341	2,489,010	2,459,896	2,426,795	2,389,493	2,347,770	2,301,393	2,250,120	2,193,699	3,965,500
Chemicals	1,393,523	1,452,223	1,513,192	1,576,512	1,642,269	1,710,552	1,781,455	1,855,072	1,931,503	2,010,850	2,093,220	2,178,722	2,267,471	2,359,583	2,455,182
Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**5,714,063**	**5,922,312**	**6,137,953**	**6,361,249**	**6,501,603**	**6,622,089**	**6,743,896**	**6,866,992**	**6,991,344**	**7,116,915**	**7,243,666**	**7,371,553**	**7,500,528**	**7,630,540**	**9,595,166**
R&R Costs:															
R&R	0	513,723	529,134	545,009	561,359	578,200	595,546	613,412	631,814	650,769	670,292	690,400	711,112	732,446	754,419
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**835,083**	**860,135**	**885,939**	**912,518**	**939,893**	**968,090**	**997,133**	**1,027,047**	**1,057,858**	**1,089,594**	**1,122,281**	**1,155,950**	**1,190,628**	**1,226,347**
Net escalated benefit/(cost)	**(309,642,769)**	**(4,707,980)**	**(4,867,640)**	**(5,032,689)**	**(5,160,479)**	**(5,279,446)**	**(5,400,849)**	**(5,524,725)**	**(5,651,113)**	**(5,782,261)**	**(5,916,129)**	**(6,052,760)**	**(6,192,200)**	**(6,334,491)**	**(7,463,332)**
Life cycle cost analysis															
PVs in 2021	(309,642,769)	(4,615,666)	(4,678,623)	(4,742,415)	(4,767,485)	(4,781,757)	(4,795,799)	(4,809,606)	(4,823,171)	(4,838,337)	(4,853,286)	(4,868,012)	(4,882,507)	(4,896,768)	(5,656,273)
NPV as of 2021	**(472,894,969)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 3A - Thermal Drying

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Year	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Capital Project															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	93,041	94,010	94,978	95,947	96,916	97,885	98,853	99,822	100,791	101,759	102,728	103,697	104,665	105,634	106,603
Energy Offset	2,143,848	2,159,615	2,175,382	2,191,148	2,207,423	2,223,190	2,238,956	2,254,723	2,270,489	2,286,256	2,266,457	2,230,400	2,194,342	2,192,603	2,190,865
Total benefits	**2,236,889**	**2,253,625**	**2,270,360**	**2,287,095**	**2,304,339**	**2,321,074**	**2,337,809**	**2,354,545**	**2,371,280**	**2,388,015**	**2,369,185**	**2,334,096**	**2,299,008**	**2,298,238**	**2,297,468**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	892,885	924,736	957,621	991,573	1,026,624	1,062,807	1,100,158	1,138,713	1,178,507	1,219,580	1,261,970	1,305,716	1,350,862	1,397,449	1,445,520
Natural Gas	2,649,245	2,676,828	2,704,411	2,731,994	2,759,577	2,787,160	2,814,743	2,842,326	2,869,909	2,897,492	2,847,474	2,763,087	2,678,701	2,594,315	2,509,928
Chemicals	1,639,567	1,655,970	1,672,373	1,688,776	1,705,179	1,721,582	1,737,985	1,754,388	1,770,791	1,787,194	1,803,597	1,820,000	1,836,403	1,852,806	1,893,239
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs	**6,710,498**	**6,786,334**	**6,863,206**	**6,941,143**	**7,020,180**	**7,100,350**	**7,181,687**	**7,264,227**	**7,348,007**	**7,433,066**	**7,441,840**	**7,417,604**	**7,394,766**	**7,373,369**	**7,377,488**
R&R Costs:															
R&R	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**
Net Benefit/(cost)	**(5,284,368)**	**(5,343,470)**	**(5,403,606)**	**(5,464,808)**	**(5,526,601)**	**(5,590,035)**	**(5,654,637)**	**(5,720,442)**	**(5,787,487)**	**(5,855,810)**	**(5,883,415)**	**(5,894,267)**	**(5,906,518)**	**(5,885,891)**	**(5,890,780)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	144,955	150,858	156,985	163,344	169,942	176,790	183,896	191,269	198,919	206,856	215,090	223,632	232,492	241,683	251,217
Energy Offset	3,340,046	3,465,548	3,595,574	3,730,283	3,870,729	4,015,328	4,165,118	4,320,282	4,481,007	4,647,488	4,745,458	4,810,060	4,874,268	5,016,518	5,162,916
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,485,000**	**3,616,406**	**3,752,559**	**3,893,627**	**4,040,672**	**4,192,118**	**4,349,014**	**4,511,551**	**4,679,926**	**4,854,344**	**4,960,548**	**5,033,692**	**5,106,760**	**5,258,202**	**5,414,133**
Annual Running Costs:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	892,885	924,736	957,621	991,573	1,026,624	1,062,807	1,100,158	1,138,713	1,178,507	1,219,580	1,261,970	1,305,716	1,350,862	1,397,449	1,445,520
Natural Gas	4,127,438	4,295,524	4,469,980	4,651,037	4,838,935	5,033,921	5,236,251	5,446,191	5,664,014	5,890,004	5,961,977	5,958,850	5,950,169	5,935,604	5,914,810
Chemicals	2,554,392	2,657,346	2,764,178	2,875,028	2,990,042	3,109,369	3,233,164	3,361,589	3,494,809	3,632,997	3,776,332	3,924,996	4,079,182	4,239,086	4,461,543
Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**9,956,536**	**10,330,881**	**10,718,653**	**11,120,318**	**11,536,361**	**11,967,280**	**12,413,592**	**12,875,831**	**13,354,549**	**13,850,317**	**14,201,246**	**14,486,559**	**14,776,119**	**15,069,923**	**15,424,591**
R&R Costs:															
R&R	777,052	800,363	824,374	849,106	874,579	900,816	927,841	955,676	984,346	1,013,876	1,044,293	1,075,621	1,107,890	1,141,127	1,175,361
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**1,263,138**	**1,301,032**	**1,340,063**	**1,380,265**	**1,421,673**	**1,464,323**	**1,508,252**	**1,553,500**	**1,600,105**	**1,648,108**	**1,697,551**	**1,748,478**	**1,800,932**	**1,854,960**	**1,910,609**
Net escalated benefit/(cost)	**(7,734,673)**	**(8,015,507)**	**(8,306,156)**	**(8,606,956)**	**(8,917,362)**	**(9,239,485)**	**(9,572,831)**	**(9,917,780)**	**(10,274,728)**	**(10,644,082)**	**(10,938,250)**	**(11,201,345)**	**(11,470,291)**	**(11,666,681)**	**(11,921,067)**
Life cycle cost analysis															
PVs in 2021	(5,746,976)	(5,838,862)	(5,931,946)	(6,026,241)	(6,121,151)	(6,217,909)	(6,315,922)	(6,415,207)	(6,515,779)	(6,617,654)	(6,667,201)	(6,693,692)	(6,720,008)	(6,701,045)	(6,712,899)
NPV as of 2021	**(472,894,969)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 3B - Thermal Drying

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	199,000,000														
Screening	15,600,000														
Total capital outlays	**214,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	78,510	79,479	80,448	81,417	82,385	83,354	84,323	85,291	86,260	87,229	88,197	89,166	90,135	91,104	92,072
Energy Offset	1,892,784	1,910,244	1,927,704	1,945,164	1,919,946	1,885,582	1,851,218	1,816,854	1,782,490	1,746,433	1,710,375	1,674,318	1,638,260	1,602,203	2,128,082
Total benefits	**1,971,294**	**1,989,723**	**2,008,152**	**2,026,581**	**2,002,331**	**1,968,936**	**1,935,541**	**1,902,145**	**1,868,750**	**1,833,661**	**1,798,573**	**1,763,484**	**1,728,395**	**1,693,306**	**2,220,154**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	556,239	564,447	572,688	580,961	602,570	624,897	647,963	671,792	696,408	721,834	748,097	775,221	803,235	832,164	862,038
Natural Gas	2,235,501	2,263,084	2,290,667	2,318,250	2,253,279	2,168,893	2,084,507	2,000,120	1,915,734	1,831,348	1,746,961	1,662,575	1,578,189	1,493,802	2,621,663
Chemicals	1,393,523	1,409,926	1,426,329	1,442,732	1,459,135	1,475,538	1,491,941	1,508,344	1,524,746	1,541,149	1,557,552	1,573,955	1,590,358	1,606,761	1,623,164
	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs	**5,714,063**	**5,766,257**	**5,818,484**	**5,870,743**	**5,843,785**	**5,798,128**	**5,753,211**	**5,709,056**	**5,665,688**	**5,623,131**	**5,581,411**	**5,540,552**	**5,500,581**	**5,461,527**	**6,635,664**
R&R Costs:															
R&R		498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**
Net Benefit/(cost)	**(218,342,769)**	**(4,587,294)**	**(4,621,092)**	**(4,654,922)**	**(4,652,214)**	**(4,639,952)**	**(4,628,430)**	**(4,617,671)**	**(4,607,698)**	**(4,600,230)**	**(4,593,598)**	**(4,587,828)**	**(4,582,946)**	**(4,578,981)**	**(5,226,271)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	199,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**214,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Class A Pellets	78,510	81,863	85,347	88,966	92,725	96,630	100,686	104,898	109,272	113,814	118,530	123,427	128,511	133,789	139,268
Energy Offset	1,892,784	1,967,551	2,045,101	2,125,534	2,160,916	2,185,906	2,210,451	2,234,501	2,258,005	2,278,698	2,298,601	2,317,647	2,335,767	2,352,889	3,218,914
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**1,971,294**	**2,049,415**	**2,130,448**	**2,214,500**	**2,253,641**	**2,282,536**	**2,311,137**	**2,339,399**	**2,367,277**	**2,392,512**	**2,417,131**	**2,441,074**	**2,464,278**	**2,486,677**	**3,358,182**
Annual Running Costs:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	556,239	564,447	572,688	580,961	602,570	624,897	647,963	671,792	696,408	721,834	748,097	775,221	803,235	832,164	862,038
Natural Gas	2,235,501	2,330,977	2,430,169	2,533,215	2,536,086	2,514,341	2,489,010	2,459,896	2,426,795	2,389,493	2,347,770	2,301,393	2,250,120	2,193,699	3,965,500
Chemicals	1,393,523	1,452,223	1,513,192	1,576,512	1,642,269	1,710,552	1,781,455	1,855,072	1,931,503	2,010,850	2,093,220	2,178,722	2,267,471	2,359,583	2,455,182
0	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**5,714,063**	**5,922,312**	**6,137,953**	**6,361,249**	**6,501,603**	**6,622,089**	**6,743,896**	**6,866,992**	**6,991,344**	**7,116,915**	**7,243,666**	**7,371,553**	**7,500,528**	**7,630,540**	**9,595,166**
R&R Costs:															
R&R	0	513,723	529,134	545,009	561,359	578,200	595,546	613,412	631,814	650,769	670,292	690,400	711,112	732,446	754,419
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**835,083**	**860,135**	**885,939**	**912,518**	**939,893**	**968,090**	**997,133**	**1,027,047**	**1,057,858**	**1,089,594**	**1,122,281**	**1,155,950**	**1,190,628**	**1,226,347**
Net escalated benefit/(cost)	**(218,342,769)**	**(4,707,980)**	**(4,867,640)**	**(5,032,689)**	**(5,160,479)**	**(5,279,446)**	**(5,400,849)**	**(5,524,725)**	**(5,651,113)**	**(5,782,261)**	**(5,916,129)**	**(6,052,760)**	**(6,192,200)**	**(6,334,491)**	**(7,463,332)**
Life cycle cost analysis															
PVs in 2021	(218,342,769)	(4,615,666)	(4,678,623)	(4,742,415)	(4,767,485)	(4,781,757)	(4,795,799)	(4,809,606)	(4,823,171)	(4,838,337)	(4,853,286)	(4,868,012)	(4,882,507)	(4,896,768)	(5,656,273)
NPV as of 2021	**(381,594,969)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 3B - Thermal Drying

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

		Year														
		2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)																
Capital Outlays																
Capital Project																
Screening																
Total capital outlays		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:																
Class A Pellets		93,041	94,010	94,978	95,947	96,916	97,885	98,853	99,822	100,791	101,759	102,728	103,697	104,665	105,634	106,603
Energy Offset		2,143,848	2,159,615	2,175,382	2,191,148	2,207,423	2,223,190	2,238,956	2,254,723	2,270,489	2,286,256	2,266,457	2,230,400	2,194,342	2,192,603	2,190,865
Total benefits		**2,236,889**	**2,253,625**	**2,270,360**	**2,287,095**	**2,304,339**	**2,321,074**	**2,337,809**	**2,354,545**	**2,371,280**	**2,388,015**	**2,369,185**	**2,334,096**	**2,299,008**	**2,298,238**	**2,297,468**
Annual Running Costs:																
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition		892,885	924,736	957,621	991,573	1,026,624	1,062,807	1,100,158	1,138,713	1,178,507	1,219,580	1,261,970	1,305,716	1,350,862	1,397,449	1,445,520
Natural Gas		2,649,245	2,676,828	2,704,411	2,731,994	2,759,577	2,787,160	2,814,743	2,842,326	2,869,909	2,897,492	2,847,474	2,763,087	2,678,701	2,594,315	2,509,928
Chemicals		1,639,567	1,655,970	1,672,373	1,688,776	1,705,179	1,721,582	1,737,985	1,754,388	1,770,791	1,787,194	1,803,597	1,820,000	1,836,403	1,852,806	1,893,239
		1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs		**6,710,498**	**6,786,334**	**6,863,206**	**6,941,143**	**7,020,180**	**7,100,350**	**7,181,687**	**7,264,227**	**7,348,007**	**7,433,066**	**7,441,840**	**7,417,604**	**7,394,766**	**7,373,369**	**7,377,488**
R&R Costs:																
R&R		498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760	498,760
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments		**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**	**810,760**
Net Benefit/(cost)		**(5,284,368)**	**(5,343,470)**	**(5,403,606)**	**(5,464,808)**	**(5,526,601)**	**(5,590,035)**	**(5,654,637)**	**(5,720,442)**	**(5,787,487)**	**(5,855,810)**	**(5,883,415)**	**(5,894,267)**	**(5,906,518)**	**(5,885,891)**	**(5,890,780)**
Expressed in escalated dollars with sensitivity adjustments																
Capital Outlays																
Capital Project		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:																
Class A Pellets		144,955	150,858	156,985	163,344	169,942	176,790	183,896	191,269	198,919	206,856	215,090	223,632	232,492	241,683	251,217
Energy Offset		3,340,046	3,465,548	3,595,574	3,730,283	3,870,729	4,015,328	4,165,118	4,320,282	4,481,007	4,647,488	4,745,458	4,810,060	4,874,268	5,016,518	5,162,916
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits		**3,485,000**	**3,616,406**	**3,752,559**	**3,893,627**	**4,040,672**	**4,192,118**	**4,349,014**	**4,511,551**	**4,679,926**	**4,854,344**	**4,960,548**	**5,033,692**	**5,106,760**	**5,258,202**	**5,414,133**
Annual Running Costs:																
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition		892,885	924,736	957,621	991,573	1,026,624	1,062,807	1,100,158	1,138,713	1,178,507	1,219,580	1,261,970	1,305,716	1,350,862	1,397,449	1,445,520
Natural Gas		4,127,438	4,295,524	4,469,980	4,651,037	4,838,935	5,033,921	5,236,251	5,446,191	5,664,014	5,890,004	5,961,977	5,958,850	5,950,169	5,935,604	5,914,810
Chemicals		2,554,392	2,657,346	2,764,178	2,875,028	2,990,042	3,109,369	3,233,164	3,361,589	3,494,809	3,632,997	3,776,332	3,924,996	4,079,182	4,239,086	4,461,543
	0	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs		**9,956,536**	**10,330,881**	**10,718,653**	**11,120,318**	**11,536,361**	**11,967,280**	**12,413,592**	**12,875,831**	**13,354,549**	**13,850,317**	**14,201,246**	**14,486,559**	**14,776,119**	**15,069,923**	**15,424,591**
R&R Costs:																
R&R		777,052	800,363	824,374	849,106	874,579	900,816	927,841	955,676	984,346	1,013,876	1,044,293	1,075,621	1,107,890	1,141,127	1,175,361
Screening		486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments		**1,263,138**	**1,301,032**	**1,340,063**	**1,380,265**	**1,421,673**	**1,464,323**	**1,508,252**	**1,553,500**	**1,600,105**	**1,648,108**	**1,697,551**	**1,748,478**	**1,800,932**	**1,854,960**	**1,910,609**
Net escalated benefit/(cost)		**(7,734,673)**	**(8,015,507)**	**(8,306,156)**	**(8,606,956)**	**(8,917,362)**	**(9,239,485)**	**(9,572,831)**	**(9,917,780)**	**(10,274,728)**	**(10,644,082)**	**(10,938,250)**	**(11,201,345)**	**(11,470,291)**	**(11,666,681)**	**(11,921,067)**
Life cycle cost analysis																
PVs in 2021		(5,746,976)	(5,838,862)	(5,931,946)	(6,026,241)	(6,121,151)	(6,217,909)	(6,315,922)	(6,415,207)	(6,515,779)	(6,617,654)	(6,667,201)	(6,693,692)	(6,720,008)	(6,701,045)	(6,712,899)
NPV as of 2021		**(381,594,969)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4A - Lystek (100%) with Storage

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	172,900,000														
Screening	15,600,000														
Total capital outlays	**188,500,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,157,751	2,175,211	2,192,671	2,210,132	2,184,913	2,150,549	2,116,185	2,081,821	2,047,458	2,011,400	1,975,343	1,939,285	1,903,227	1,867,170	2,393,049
Total benefits	**2,157,751**	**2,175,211**	**2,192,671**	**2,210,132**	**2,184,913**	**2,150,549**	**2,116,185**	**2,081,821**	**2,047,458**	**2,011,400**	**1,975,343**	**1,939,285**	**1,903,227**	**1,867,170**	**2,393,049**
Annual Running Costs:															
Biosolids Disposition	5,332,908	5,411,601	5,490,609	5,569,930	5,777,107	5,991,162	6,212,309	6,440,768	6,676,768	6,920,542	7,172,332	7,432,387	7,700,961	7,978,319	8,264,731
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	3,420,113	3,462,182	3,504,252	3,546,322	3,588,391	3,630,461	3,672,530	3,714,600	3,756,669	3,798,739	3,840,808	3,882,878	3,924,947	3,967,017	4,009,086
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**10,331,821**	**10,452,584**	**10,573,661**	**10,695,052**	**10,944,298**	**11,200,422**	**11,463,639**	**11,734,168**	**12,012,237**	**12,298,081**	**12,591,941**	**12,894,064**	**13,204,708**	**13,524,136**	**13,852,618**
R&R Costs:															
R&R		202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(196,674,070)**	**(8,791,373)**	**(8,894,989)**	**(8,998,920)**	**(9,273,385)**	**(9,563,873)**	**(9,861,453)**	**(10,166,346)**	**(10,478,780)**	**(10,800,681)**	**(11,130,598)**	**(11,468,779)**	**(11,815,481)**	**(12,170,966)**	**(11,973,569)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	172,900,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**188,500,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,157,751	2,240,468	2,326,205	2,415,071	2,459,139	2,493,076	2,526,836	2,560,378	2,593,658	2,624,421	2,654,695	2,684,424	2,713,547	2,742,002	3,619,701
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,157,751**	**2,240,468**	**2,326,205**	**2,415,071**	**2,459,139**	**2,493,076**	**2,526,836**	**2,560,378**	**2,593,658**	**2,624,421**	**2,654,695**	**2,684,424**	**2,713,547**	**2,742,002**	**3,619,701**
Annual Running Costs:															
Biosolids Disposition	5,332,908	5,411,601	5,490,609	5,569,930	5,777,107	5,991,162	6,212,309	6,440,768	6,676,768	6,920,542	7,172,332	7,432,387	7,700,961	7,978,319	8,264,731
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	3,420,113	3,566,048	3,717,661	3,875,161	4,038,766	4,208,699	4,385,193	4,568,489	4,758,836	4,956,492	5,161,725	5,374,811	5,596,036	5,825,698	6,064,103
Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
Annual Licensing fees	50,000	51,500	53,045	54,636	56,275	57,964	59,703	61,494	63,339	65,239	67,196	69,212	71,288	73,427	75,629
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**10,331,821**	**10,603,813**	**10,883,218**	**11,170,289**	**11,592,826**	**12,030,123**	**12,482,671**	**12,950,982**	**13,435,581**	**13,937,011**	**14,455,833**	**14,992,626**	**15,547,989**	**16,122,538**	**16,716,911**
R&R Costs:															
R&R	0	208,060	214,302	220,731	227,353	234,173	241,199	248,435	255,888	263,564	271,471	279,615	288,004	296,644	305,543
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**529,420**	**545,303**	**561,662**	**578,512**	**595,867**	**613,743**	**632,155**	**651,120**	**670,653**	**690,773**	**711,496**	**732,841**	**754,826**	**777,471**
Net escalated benefit/(cost)	**(196,674,070)**	**(8,892,766)**	**(9,102,316)**	**(9,316,880)**	**(9,712,199)**	**(10,132,913)**	**(10,569,578)**	**(11,022,759)**	**(11,493,043)**	**(11,983,243)**	**(12,491,911)**	**(13,019,698)**	**(13,567,282)**	**(14,135,362)**	**(13,874,681)**
Life cycle cost analysis															
PVs in 2021	(196,674,070)	(8,718,398)	(8,748,862)	(8,779,504)	(8,972,570)	(9,177,692)	(9,385,483)	(9,595,975)	(9,809,201)	(10,027,042)	(10,247,718)	(10,471,262)	(10,697,710)	(10,927,095)	(10,515,274)
NPV as of 2021	**(512,626,991)**														

From Summary Sheet:

Year of analysis	**2021**	**Benefits**	**0%**
Escalation rate	**3.00%**	**Capital costs**	**0%**
Discount rate	**2.00%**	**Running costs**	**0%**

Risk adjustments (+/- percent):

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4A - Lystek (100%) with Storage

	Year														
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Capital Project															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,408,816	2,424,582	2,440,349	2,456,116	2,472,390	2,488,157	2,503,924	2,519,690	2,535,457	2,551,224	2,531,425	2,495,367	2,459,310	2,445,337	2,431,365
Total benefits	**2,408,816**	**2,424,582**	**2,440,349**	**2,456,116**	**2,472,390**	**2,488,157**	**2,503,924**	**2,519,690**	**2,535,457**	**2,551,224**	**2,531,425**	**2,495,367**	**2,459,310**	**2,445,337**	**2,431,365**
Annual Running Costs:															
Biosolids Disposition	8,560,478	8,865,847	9,181,133	9,506,643	9,842,690	10,189,598	10,547,700	10,917,338	11,298,866	11,692,647	12,099,055	12,518,475	12,951,305	13,397,952	13,858,837
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	4,051,156	4,093,225	4,135,295	4,177,365	4,219,434	4,261,504	4,303,573	4,345,643	4,387,712	4,429,782	4,471,851	4,513,921	4,555,990	4,598,060	4,640,129
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**14,190,434**	**14,537,872**	**14,895,228**	**15,262,808**	**15,640,924**	**16,029,902**	**16,430,073**	**16,841,781**	**17,265,378**	**17,701,228**	**18,149,706**	**18,611,196**	**19,086,095**	**19,574,812**	**20,077,767**
R&R Costs:															
R&R	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(12,295,618)**	**(12,627,290)**	**(12,968,879)**	**(13,320,692)**	**(13,682,534)**	**(14,055,745)**	**(14,440,149)**	**(14,836,090)**	**(15,243,921)**	**(15,664,005)**	**(16,132,281)**	**(16,629,829)**	**(17,140,786)**	**(17,643,475)**	**(18,160,402)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,752,856	3,890,743	4,033,525	4,181,372	4,335,351	4,493,888	4,658,035	4,827,987	5,003,943	5,186,112	5,300,241	5,381,487	5,462,837	5,594,754	5,729,670
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,752,856**	**3,890,743**	**4,033,525**	**4,181,372**	**4,335,351**	**4,493,888**	**4,658,035**	**4,827,987**	**5,003,943**	**5,186,112**	**5,300,241**	**5,381,487**	**5,462,837**	**5,594,754**	**5,729,670**
Annual Running Costs:															
Biosolids Disposition	8,560,478	8,865,847	9,181,133	9,506,643	9,842,690	10,189,598	10,547,700	10,917,338	11,298,866	11,692,647	12,099,055	12,518,475	12,951,305	13,397,952	13,858,837
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	6,311,569	6,568,425	6,835,013	7,111,684	7,398,803	7,696,750	8,005,914	8,326,701	8,659,530	9,004,834	9,363,064	9,734,682	10,120,171	10,520,028	10,934,769
Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
Annual Licensing fees	77,898	80,235	82,642	85,122	87,675	90,306	93,015	95,805	98,679	101,640	104,689	107,830	111,064	114,396	117,828
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**17,331,766**	**17,967,782**	**18,625,662**	**19,306,128**	**20,009,929**	**20,737,836**	**21,490,647**	**22,269,183**	**23,074,294**	**23,906,856**	**24,767,775**	**25,657,984**	**26,578,447**	**27,530,161**	**28,514,152**
R&R Costs:															
R&R	314,709	324,151	333,875	343,891	354,208	364,834	375,780	387,053	398,664	410,624	422,943	435,631	448,700	462,161	476,026
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**800,795**	**824,819**	**849,564**	**875,051**	**901,302**	**928,341**	**956,191**	**984,877**	**1,014,423**	**1,044,856**	**1,076,202**	**1,108,488**	**1,141,743**	**1,175,995**	**1,211,275**
Net escalated benefit/(cost)	**(14,379,705)**	**(14,901,859)**	**(15,441,700)**	**(15,999,806)**	**(16,575,880)**	**(17,172,289)**	**(17,788,803)**	**(18,426,073)**	**(19,084,774)**	**(19,765,600)**	**(20,543,736)**	**(21,384,985)**	**(22,257,353)**	**(23,111,401)**	**(23,995,756)**
Life cycle cost analysis															
PVs in 2021	(10,684,333)	(10,855,197)	(11,027,884)	(11,202,414)	(11,378,194)	(11,556,458)	(11,736,622)	(11,918,703)	(12,102,722)	(12,288,698)	(12,522,041)	(12,779,224)	(13,039,738)	(13,274,601)	(13,512,306)
NPV as of 2021	**(512,626,991)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4B Lystek 100% w/o storage

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	78,000,000														
Screening	15,600,000														
Total capital outlays	**93,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,157,751	2,175,211	2,192,671	2,210,132	2,184,913	2,150,549	2,116,185	2,081,821	2,047,458	2,011,400	1,975,343	1,939,285	1,903,227	1,867,170	2,393,049
Total benefits	**2,157,751**	**2,175,211**	**2,192,671**	**2,210,132**	**2,184,913**	**2,150,549**	**2,116,185**	**2,081,821**	**2,047,458**	**2,011,400**	**1,975,343**	**1,939,285**	**1,903,227**	**1,867,170**	**2,393,049**
Annual Running Costs:															
Biosolids Disposition	5,332,908	5,411,601	5,490,609	5,569,930	5,777,107	5,991,162	6,212,309	6,440,768	6,676,768	6,920,542	7,172,332	7,432,387	7,700,961	7,978,319	8,264,731
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	3,420,113	3,462,182	3,504,252	3,546,322	3,588,391	3,630,461	3,672,530	3,714,600	3,756,669	3,798,739	3,840,808	3,882,878	3,924,947	3,967,017	4,009,086
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**10,331,821**	**10,452,584**	**10,573,661**	**10,695,052**	**10,944,298**	**11,200,422**	**11,463,639**	**11,734,168**	**12,012,237**	**12,298,081**	**12,591,941**	**12,894,064**	**13,204,708**	**13,524,136**	**13,852,618**
R&R Costs:															
R&R		202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(101,774,070)**	**(8,791,373)**	**(8,894,989)**	**(8,998,920)**	**(9,273,385)**	**(9,563,873)**	**(9,861,453)**	**(10,166,346)**	**(10,478,780)**	**(10,800,681)**	**(11,130,598)**	**(11,468,779)**	**(11,815,481)**	**(12,170,966)**	**(11,973,569)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	78,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**93,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,157,751	2,240,468	2,326,205	2,415,071	2,459,139	2,493,076	2,526,836	2,560,378	2,593,658	2,624,421	2,654,695	2,684,424	2,713,547	2,742,002	3,619,701
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,157,751**	**2,240,468**	**2,326,205**	**2,415,071**	**2,459,139**	**2,493,076**	**2,526,836**	**2,560,378**	**2,593,658**	**2,624,421**	**2,654,695**	**2,684,424**	**2,713,547**	**2,742,002**	**3,619,701**
Annual Running Costs:															
Biosolids Disposition	5,332,908	5,411,601	5,490,609	5,569,930	5,777,107	5,991,162	6,212,309	6,440,768	6,676,768	6,920,542	7,172,332	7,432,387	7,700,961	7,978,319	8,264,731
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	3,420,113	3,566,048	3,717,661	3,875,161	4,038,766	4,208,699	4,385,193	4,568,489	4,758,836	4,956,492	5,161,725	5,374,811	5,596,036	5,825,698	6,064,103
Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
Annual Licensing fees	50,000	51,500	53,045	54,636	56,275	57,964	59,703	61,494	63,339	65,239	67,196	69,212	71,288	73,427	75,629
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**10,331,821**	**10,603,813**	**10,883,218**	**11,170,289**	**11,592,826**	**12,030,123**	**12,482,671**	**12,950,982**	**13,435,581**	**13,937,011**	**14,455,833**	**14,992,626**	**15,547,989**	**16,122,538**	**16,716,911**
R&R Costs:															
R&R	0	208,060	214,302	220,731	227,353	234,173	241,199	248,435	255,888	263,564	271,471	279,615	288,004	296,644	305,543
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**529,420**	**545,303**	**561,662**	**578,512**	**595,867**	**613,743**	**632,155**	**651,120**	**670,653**	**690,773**	**711,496**	**732,841**	**754,826**	**777,471**
Net escalated benefit/(cost)	**(101,774,070)**	**(8,892,766)**	**(9,102,316)**	**(9,316,880)**	**(9,712,199)**	**(10,132,913)**	**(10,569,578)**	**(11,022,759)**	**(11,493,043)**	**(11,983,243)**	**(12,491,911)**	**(13,019,698)**	**(13,567,282)**	**(14,135,362)**	**(13,874,681)**
Life cycle cost analysis															
PVs in 2021	(101,774,070)	(8,718,398)	(8,748,862)	(8,779,504)	(8,972,570)	(9,177,692)	(9,385,483)	(9,595,975)	(9,809,201)	(10,027,042)	(10,247,718)	(10,471,262)	(10,697,710)	(10,927,095)	(10,515,274)
NPV as of 2021	**(417,726,991)**														

From Summary Sheet:

Year of analysis	**2021**	**Benefits**	**0%**
Escalation rate	**3.00%**	**Capital costs**	**0%**
Discount rate	**2.00%**	**Running costs**	**0%**

Risk adjustments (+/- percent):

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4B Lystek 100% w/o storage

	Year														
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Capital Project															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,408,816	2,424,582	2,440,349	2,456,116	2,472,390	2,488,157	2,503,924	2,519,690	2,535,457	2,551,224	2,531,425	2,495,367	2,459,310	2,445,337	2,431,365
Total benefits	**2,408,816**	**2,424,582**	**2,440,349**	**2,456,116**	**2,472,390**	**2,488,157**	**2,503,924**	**2,519,690**	**2,535,457**	**2,551,224**	**2,531,425**	**2,495,367**	**2,459,310**	**2,445,337**	**2,431,365**
Annual Running Costs:															
Biosolids Disposition	8,560,478	8,865,847	9,181,133	9,506,643	9,842,690	10,189,598	10,547,700	10,917,338	11,298,866	11,692,647	12,099,055	12,518,475	12,951,305	13,397,952	13,858,837
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	4,051,156	4,093,225	4,135,295	4,177,365	4,219,434	4,261,504	4,303,573	4,345,643	4,387,712	4,429,782	4,471,851	4,513,921	4,555,990	4,598,060	4,640,129
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**14,190,434**	**14,537,872**	**14,895,228**	**15,262,808**	**15,640,924**	**16,029,902**	**16,430,073**	**16,841,781**	**17,265,378**	**17,701,228**	**18,149,706**	**18,611,196**	**19,086,095**	**19,574,812**	**20,077,767**
R&R Costs:															
R&R	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(12,295,618)**	**(12,627,290)**	**(12,968,879)**	**(13,320,692)**	**(13,682,534)**	**(14,055,745)**	**(14,440,149)**	**(14,836,090)**	**(15,243,921)**	**(15,664,005)**	**(16,132,281)**	**(16,629,829)**	**(17,140,786)**	**(17,643,475)**	**(18,160,402)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,752,856	3,890,743	4,033,525	4,181,372	4,335,351	4,493,888	4,658,035	4,827,987	5,003,943	5,186,112	5,300,241	5,381,487	5,462,837	5,594,754	5,729,670
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,752,856**	**3,890,743**	**4,033,525**	**4,181,372**	**4,335,351**	**4,493,888**	**4,658,035**	**4,827,987**	**5,003,943**	**5,186,112**	**5,300,241**	**5,381,487**	**5,462,837**	**5,594,754**	**5,729,670**
Annual Running Costs:															
Biosolids Disposition	8,560,478	8,865,847	9,181,133	9,506,643	9,842,690	10,189,598	10,547,700	10,917,338	11,298,866	11,692,647	12,099,055	12,518,475	12,951,305	13,397,952	13,858,837
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	6,311,569	6,568,425	6,835,013	7,111,684	7,398,803	7,696,750	8,005,914	8,326,701	8,659,530	9,004,834	9,363,064	9,734,682	10,120,171	10,520,028	10,934,769
Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
Annual Licensing fees	77,898	80,235	82,642	85,122	87,675	90,306	93,015	95,805	98,679	101,640	104,689	107,830	111,064	114,396	117,828
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**17,331,766**	**17,967,782**	**18,625,662**	**19,306,128**	**20,009,929**	**20,737,836**	**21,490,647**	**22,269,183**	**23,074,294**	**23,906,856**	**24,767,775**	**25,657,984**	**26,578,447**	**27,530,161**	**28,514,152**
R&R Costs:															
R&R	314,709	324,151	333,875	343,891	354,208	364,834	375,780	387,053	398,664	410,624	422,943	435,631	448,700	462,161	476,026
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**800,795**	**824,819**	**849,564**	**875,051**	**901,302**	**928,341**	**956,191**	**984,877**	**1,014,423**	**1,044,856**	**1,076,202**	**1,108,488**	**1,141,743**	**1,175,995**	**1,211,275**
Net escalated benefit/(cost)	**(14,379,705)**	**(14,901,859)**	**(15,441,700)**	**(15,999,806)**	**(16,575,880)**	**(17,172,289)**	**(17,788,803)**	**(18,426,073)**	**(19,084,774)**	**(19,765,600)**	**(20,543,736)**	**(21,384,985)**	**(22,257,353)**	**(23,111,401)**	**(23,995,756)**
Life cycle cost analysis															
PVs in 2021	(10,684,333)	(10,855,197)	(11,027,884)	(11,202,414)	(11,378,194)	(11,556,458)	(11,736,622)	(11,918,703)	(12,102,722)	(12,288,698)	(12,522,041)	(12,779,224)	(13,039,738)	(13,274,601)	(13,512,306)
NPV as of 2021	**(417,726,991)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4C (33% operation)

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	78,000,000														
Screening	15,600,000														
Total capital outlays	**93,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,201,492	2,218,952	2,236,412	2,253,872	2,228,654	2,194,290	2,159,926	2,125,562	2,091,198	2,055,141	2,019,083	1,983,026	1,946,968	1,910,911	2,436,790
Total benefits	**2,201,492**	**2,218,952**	**2,236,412**	**2,253,872**	**2,228,654**	**2,194,290**	**2,159,926**	**2,125,562**	**2,091,198**	**2,055,141**	**2,019,083**	**1,983,026**	**1,946,968**	**1,910,911**	**2,436,790**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	3,961,640	4,020,098	4,078,790	4,137,715	4,291,620	4,450,634	4,614,917	4,784,632	4,959,948	5,141,040	5,328,087	5,521,272	5,720,787	5,926,827	6,139,593
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,343,861	1,360,409	1,376,958	1,393,507	1,410,056	1,426,605	1,443,154	1,459,703	1,476,252	1,492,800	1,509,349	1,525,898	1,542,447	1,558,996	1,575,545
Labor	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**6,119,900**	**6,194,908**	**6,270,148**	**6,345,622**	**6,516,076**	**6,691,639**	**6,872,471**	**7,058,735**	**7,250,600**	**7,448,241**	**7,651,836**	**7,861,570**	**8,077,634**	**8,300,223**	**8,529,538**
R&R Costs:															
R&R		202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(97,518,409)**	**(4,489,956)**	**(4,547,736)**	**(4,605,750)**	**(4,801,422)**	**(5,011,349)**	**(5,226,545)**	**(5,447,172)**	**(5,673,402)**	**(5,907,100)**	**(6,146,753)**	**(6,392,545)**	**(6,644,666)**	**(6,903,312)**	**(6,606,748)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	78,000,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**93,600,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,201,492	2,285,520	2,372,610	2,462,867	2,508,370	2,543,783	2,579,065	2,614,173	2,649,067	2,681,493	2,713,479	2,744,971	2,775,911	2,806,237	3,685,863
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,201,492**	**2,285,520**	**2,372,610**	**2,462,867**	**2,508,370**	**2,543,783**	**2,579,065**	**2,614,173**	**2,649,067**	**2,681,493**	**2,713,479**	**2,744,971**	**2,775,911**	**2,806,237**	**3,685,863**
Annual Running Costs:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	3,961,640	4,020,098	4,078,790	4,137,715	4,291,620	4,450,634	4,614,917	4,784,632	4,959,948	5,141,040	5,328,087	5,521,272	5,720,787	5,926,827	6,139,593
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,343,861	1,401,222	1,460,815	1,522,723	1,587,030	1,653,826	1,723,201	1,795,250	1,870,071	1,947,766	2,028,439	2,112,200	2,199,161	2,289,438	2,383,153
Labor	764,400	787,332	810,952	835,281	860,339	886,149	912,734	940,116	968,319	997,369	1,027,290	1,058,108	1,089,852	1,122,547	1,156,224
Annual Licensing fees	50,000	51,500	53,045	54,636	56,275	57,964	59,703	61,494	63,339	65,239	67,196	69,212	71,288	73,427	75,629
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**6,119,900**	**6,260,152**	**6,403,602**	**6,550,355**	**6,795,265**	**7,048,573**	**7,310,554**	**7,581,491**	**7,861,677**	**8,151,413**	**8,451,011**	**8,760,792**	**9,081,087**	**9,412,239**	**9,754,599**
R&R Costs:															
R&R	0	208,060	214,302	220,731	227,353	234,173	241,199	248,435	255,888	263,564	271,471	279,615	288,004	296,644	305,543
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**529,420**	**545,303**	**561,662**	**578,512**	**595,867**	**613,743**	**632,155**	**651,120**	**670,653**	**690,773**	**711,496**	**732,841**	**754,826**	**777,471**
Net escalated benefit/(cost)	**(97,518,409)**	**(4,504,051)**	**(4,576,295)**	**(4,649,150)**	**(4,865,407)**	**(5,100,657)**	**(5,345,232)**	**(5,599,473)**	**(5,863,730)**	**(6,140,574)**	**(6,428,305)**	**(6,727,317)**	**(7,038,017)**	**(7,360,828)**	**(6,846,207)**
Life cycle cost analysis															
PVs in 2021	(97,518,409)	(4,415,737)	(4,398,592)	(4,380,998)	(4,494,884)	(4,619,822)	(4,746,413)	(4,874,678)	(5,004,637)	(5,138,158)	(5,273,449)	(5,410,533)	(5,549,429)	(5,690,160)	(5,188,570)
NPV as of 2021	**(255,077,986)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 4C (33% operation)

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Capital Project															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,452,556	2,468,323	2,484,090	2,499,856	2,516,131	2,531,898	2,547,664	2,563,431	2,579,198	2,594,964	2,575,165	2,539,108	2,503,050	2,497,274	2,491,499
Total benefits	**2,452,556**	**2,468,323**	**2,484,090**	**2,499,856**	**2,516,131**	**2,531,898**	**2,547,664**	**2,563,431**	**2,579,198**	**2,594,964**	**2,575,165**	**2,539,108**	**2,503,050**	**2,497,274**	**2,491,499**
Annual Running Costs:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	6,359,294	6,586,142	6,820,358	7,062,168	7,311,806	7,569,513	7,835,534	8,110,126	8,393,551	8,686,077	8,987,984	9,299,558	9,621,093	9,952,892	10,295,268
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	1,592,094	1,608,643	1,625,192	1,641,740	1,658,289	1,674,838	1,691,387	1,707,936	1,724,485	1,741,034	1,757,583	1,774,131	1,790,680	1,807,229	1,823,778
Labor	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400
Annual Licensing fees	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Total running costs	**8,765,787**	**9,009,184**	**9,259,949**	**9,518,309**	**9,784,496**	**10,058,751**	**10,341,321**	**10,632,462**	**10,932,435**	**11,241,511**	**11,559,967**	**11,888,089**	**12,226,173**	**12,574,521**	**12,933,446**
R&R Costs:															
R&R	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000	202,000
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**
Net Benefit/(cost)	**(6,827,231)**	**(7,054,861)**	**(7,289,860)**	**(7,532,452)**	**(7,782,365)**	**(8,040,853)**	**(8,307,657)**	**(8,583,031)**	**(8,867,238)**	**(9,160,547)**	**(9,498,802)**	**(9,862,982)**	**(10,237,123)**	**(10,591,247)**	**(10,955,947)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	3,821,003	3,960,934	4,105,822	4,255,838	4,412,051	4,572,889	4,739,406	4,911,799	5,090,270	5,275,028	5,391,824	5,475,818	5,559,998	5,713,583	5,871,380
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,821,003**	**3,960,934**	**4,105,822**	**4,255,838**	**4,412,051**	**4,572,889**	**4,739,406**	**4,911,799**	**5,090,270**	**5,275,028**	**5,391,824**	**5,475,818**	**5,559,998**	**5,713,583**	**5,871,380**
Annual Running Costs:															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	6,359,294	6,586,142	6,820,358	7,062,168	7,311,806	7,569,513	7,835,534	8,110,126	8,393,551	8,686,077	8,987,984	9,299,558	9,621,093	9,952,892	10,295,268
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	2,480,430	2,581,399	2,686,194	2,794,953	2,907,820	3,024,944	3,146,478	3,272,582	3,403,420	3,539,163	3,679,988	3,826,076	3,977,619	4,134,810	4,297,853
Labor	1,190,910	1,226,638	1,263,437	1,301,340	1,340,380	1,380,591	1,422,009	1,464,669	1,508,610	1,553,868	1,600,484	1,648,498	1,697,953	1,748,892	1,801,359
Annual Licensing fees	77,898	80,235	82,642	85,122	87,675	90,306	93,015	95,805	98,679	101,640	104,689	107,830	111,064	114,396	117,828
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**10,108,532**	**10,474,414**	**10,852,631**	**11,243,583**	**11,647,682**	**12,065,354**	**12,497,037**	**12,943,183**	**13,404,259**	**13,880,748**	**14,373,145**	**14,881,962**	**15,407,729**	**15,950,990**	**16,512,307**
R&R Costs:															
R&R	314,709	324,151	333,875	343,891	354,208	364,834	375,780	387,053	398,664	410,624	422,943	435,631	448,700	462,161	476,026
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**800,795**	**824,819**	**849,564**	**875,051**	**901,302**	**928,341**	**956,191**	**984,877**	**1,014,423**	**1,044,856**	**1,076,202**	**1,108,488**	**1,141,743**	**1,175,995**	**1,211,275**
Net escalated benefit/(cost)	**(7,088,325)**	**(7,338,299)**	**(7,596,373)**	**(7,862,795)**	**(8,136,933)**	**(8,420,806)**	**(8,713,822)**	**(9,016,261)**	**(9,328,413)**	**(9,650,576)**	**(10,057,522)**	**(10,514,633)**	**(10,989,474)**	**(11,413,402)**	**(11,852,202)**
Life cycle cost analysis															
PVs in 2021	(5,266,730)	(5,345,553)	(5,425,045)	(5,505,210)	(5,585,441)	(5,666,961)	(5,749,169)	(5,832,070)	(5,915,669)	(5,999,971)	(6,130,370)	(6,283,327)	(6,438,315)	(6,555,567)	(6,674,121)
NPV as of 2021	**(255,077,986)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 5 - Pyrolysis

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Capital Project	354,100,000														
Screening	15,600,000														
Total capital outlays	**369,700,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Biochar	39,162	39,652	40,141	40,630	41,119	41,609	42,098	42,587	43,076	43,566	44,055	44,544	45,033	45,523	46,012
Energy Offset	2,130,273	2,182,097	2,233,921	2,285,746	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,294,891	2,856,828
Total benefits	**2,169,436**	**2,221,749**	**2,274,062**	**2,326,376**	**2,336,010**	**2,336,500**	**2,336,989**	**2,337,478**	**2,337,967**	**2,338,457**	**2,338,946**	**2,339,435**	**2,339,924**	**2,340,414**	**2,902,839**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	163,993	207,552	210,615	213,689	216,777	224,840	233,171	241,777	250,669	259,854	269,341	279,141	289,262	299,714	310,509
Natural Gas	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907
Chemicals	1,325,506	1,341,842	1,358,177	1,374,512	1,390,848	1,407,183	1,423,519	1,439,854	1,456,189	1,472,525	1,488,860	1,505,196	1,521,531	1,537,866	1,554,202
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs	**3,029,206**	**3,089,101**	**3,108,499**	**3,127,909**	**3,147,331**	**3,171,730**	**3,196,396**	**3,221,338**	**3,246,565**	**3,272,086**	**3,297,908**	**3,324,043**	**3,350,500**	**3,377,288**	**3,404,418**
R&R Costs:															
R&R		552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**0**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**
Net Benefit/(cost)	**(370,559,770)**	**(1,731,352)**	**(1,698,436)**	**(1,665,533)**	**(1,675,321)**	**(1,699,230)**	**(1,723,407)**	**(1,747,860)**	**(1,772,598)**	**(1,797,629)**	**(1,822,962)**	**(1,848,608)**	**(1,874,575)**	**(1,900,874)**	**(1,365,578)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	354,100,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**369,700,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Biochar	39,162	40,841	42,586	44,398	46,280	48,236	50,267	52,377	54,568	56,843	59,206	61,660	64,207	66,852	69,597
Energy Offset	2,130,273	2,247,560	2,369,967	2,497,696	2,582,920	2,660,408	2,740,220	2,822,427	2,907,099	2,994,312	3,084,142	3,176,666	3,271,966	3,370,125	4,321,208
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,169,436**	**2,288,401**	**2,412,553**	**2,542,094**	**2,629,200**	**2,708,644**	**2,790,487**	**2,874,803**	**2,961,667**	**3,051,156**	**3,143,348**	**3,238,325**	**3,336,173**	**3,436,976**	**4,390,805**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	163,993	207,552	210,615	213,689	216,777	224,840	233,171	241,777	250,669	259,854	269,341	279,141	289,262	299,714	310,509
Natural Gas	10,907	11,234	11,571	11,918	12,276	12,644	13,023	13,414	13,817	14,231	14,658	15,098	15,551	16,017	16,498
Chemicals	1,325,506	1,382,097	1,440,890	1,501,967	1,565,412	1,631,311	1,699,756	1,770,839	1,844,657	1,921,311	2,000,904	2,083,543	2,169,340	2,258,409	2,350,870
Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**3,029,206**	**3,175,547**	**3,284,980**	**3,398,136**	**3,515,142**	**3,641,093**	**3,771,417**	**3,906,262**	**4,045,781**	**4,190,133**	**4,339,482**	**4,493,998**	**4,653,855**	**4,819,235**	**4,990,324**
R&R Costs:															
R&R	0	568,560	585,617	603,185	621,281	639,919	659,117	678,890	699,257	720,235	741,842	764,097	787,020	810,631	834,950
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**0**	**889,920**	**916,618**	**944,116**	**972,440**	**1,001,613**	**1,031,661**	**1,062,611**	**1,094,489**	**1,127,324**	**1,161,144**	**1,195,978**	**1,231,857**	**1,268,813**	**1,306,878**
Net escalated benefit/(cost)	**(370,559,770)**	**(1,777,065)**	**(1,789,044)**	**(1,800,158)**	**(1,858,381)**	**(1,934,062)**	**(2,012,591)**	**(2,094,069)**	**(2,178,603)**	**(2,266,301)**	**(2,357,278)**	**(2,451,651)**	**(2,549,540)**	**(2,651,071)**	**(1,906,396)**
Life cycle cost analysis															
PVs in 2021	(370,559,770)	(1,742,221)	(1,719,574)	(1,696,329)	(1,716,857)	(1,751,740)	(1,787,123)	(1,823,013)	(1,859,417)	(1,896,340)	(1,933,789)	(1,971,772)	(2,010,295)	(2,049,364)	(1,444,810)
NPV as of 2021	**(416,990,661)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
Alternative 5 - Pyrolysis

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Capital Project															
Screening															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Biochar	46,501	46,990	47,480	47,969	48,458	48,947	49,437	49,926	50,415	50,904	51,394	51,883	52,372	52,861	53,351
Energy Offset	2,908,652	2,960,476	3,012,300	3,064,124	3,116,456	3,168,281	3,220,105	3,271,929	3,323,753	3,375,577	3,391,836	3,391,836	3,391,836	2,892,712	2,393,589
Total benefits	**2,955,153**	**3,007,466**	**3,059,780**	**3,112,093**	**3,164,915**	**3,217,228**	**3,269,541**	**3,321,855**	**3,374,168**	**3,426,482**	**3,443,229**	**3,443,719**	**3,444,208**	**2,945,574**	**2,446,939**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	321,656	333,166	345,051	357,321	369,990	383,069	396,570	410,507	424,893	439,742	455,067	470,884	487,208	504,053	521,436
Natural Gas	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907	10,907
Chemicals	1,570,537	1,586,873	1,603,208	1,619,543	1,635,879	1,652,214	1,668,550	1,684,885	1,701,220	1,717,556	1,733,891	1,750,227	1,766,562	1,782,898	1,799,233
Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Total running costs	**3,431,900**	**3,459,746**	**3,487,966**	**3,516,572**	**3,545,576**	**3,574,990**	**3,604,826**	**3,635,099**	**3,665,820**	**3,697,004**	**3,728,665**	**3,760,818**	**3,793,477**	**3,826,657**	**3,860,376**
R&R Costs:															
R&R	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000	552,000
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Total refurbishments	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**	**864,000**
Net Benefit/(cost)	**(1,340,747)**	**(1,316,279)**	**(1,292,186)**	**(1,268,479)**	**(1,244,661)**	**(1,221,762)**	**(1,199,285)**	**(1,177,244)**	**(1,155,652)**	**(1,134,523)**	**(1,149,436)**	**(1,181,099)**	**(1,213,269)**	**(1,745,084)**	**(2,277,437)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Capital Project	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Biochar	72,447	75,406	78,477	81,664	84,972	88,404	91,967	95,663	99,499	103,478	107,607	111,890	116,334	120,943	125,724
Energy Offset	4,531,585	4,750,695	4,978,873	5,216,466	5,464,725	5,722,267	5,990,343	6,269,354	6,559,714	6,861,853	7,101,751	7,314,803	7,534,247	6,618,316	5,640,649
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**4,604,032**	**4,826,100**	**5,057,350**	**5,298,130**	**5,549,697**	**5,810,672**	**6,082,310**	**6,365,017**	**6,659,213**	**6,965,332**	**7,209,358**	**7,426,694**	**7,650,581**	**6,739,259**	**5,766,373**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	321,656	333,166	345,051	357,321	369,990	383,069	396,570	410,507	424,893	439,742	455,067	470,884	487,208	504,053	521,436
Natural Gas	16,993	17,502	18,027	18,568	19,125	19,699	20,290	20,899	21,526	22,172	22,837	23,522	24,227	24,954	25,703
Chemicals	2,446,846	2,546,465	2,649,859	2,757,164	2,868,524	2,984,083	3,103,994	3,228,414	3,357,506	3,491,438	3,630,383	3,774,524	3,924,045	4,079,141	4,240,010
Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**5,167,315**	**5,350,408**	**5,539,810**	**5,735,734**	**5,938,399**	**6,148,033**	**6,364,872**	**6,589,159**	**6,821,143**	**7,061,086**	**7,309,255**	**7,565,926**	**7,831,387**	**8,105,932**	**8,389,866**
R&R Costs:															
R&R	859,998	885,798	912,372	939,743	967,935	996,973	1,026,883	1,057,689	1,089,420	1,122,102	1,155,765	1,190,438	1,226,152	1,262,936	1,300,824
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total refurbishments	**1,346,084**	**1,386,466**	**1,428,060**	**1,470,902**	**1,515,029**	**1,560,480**	**1,607,295**	**1,655,513**	**1,705,179**	**1,756,334**	**1,809,024**	**1,863,295**	**1,919,194**	**1,976,770**	**2,036,073**
Net escalated benefit/(cost)	**(1,909,367)**	**(1,910,774)**	**(1,910,521)**	**(1,908,506)**	**(1,903,731)**	**(1,897,842)**	**(1,889,857)**	**(1,879,655)**	**(1,867,109)**	**(1,852,089)**	**(1,908,921)**	**(2,002,528)**	**(2,099,999)**	**(3,343,442)**	**(4,659,566)**
Life cycle cost analysis															
PVs in 2021	(1,418,688)	(1,391,896)	(1,364,423)	(1,336,258)	(1,306,780)	(1,277,193)	(1,246,882)	(1,215,834)	(1,184,038)	(1,151,483)	(1,163,546)	(1,196,669)	(1,230,310)	(1,920,388)	(2,623,859)
NPV as of 2021	**(416,990,661)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
2 Month Storage, Contract Haul, at Pinole

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Pinole	44,200,000														
Front Loader	170,000														
Total capital outlays	**59,970,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,262,103	5,484,941	5,720,692	5,970,231	5,883,349	6,101,340	6,326,554	6,559,215	6,799,555	7,047,812	7,304,233	7,569,070	7,842,583	8,125,042	8,416,721
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400
Odor Control Chemicals	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410
Total running costs	**7,362,841**	**7,602,014**	**7,854,100**	**8,119,976**	**8,049,429**	**8,283,755**	**8,525,304**	**8,774,301**	**9,030,976**	**9,295,569**	**9,568,325**	**9,849,497**	**10,139,346**	**10,438,140**	**10,746,155**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site		20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total refurbishments	**0**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**
Net Benefit/(cost)	**(65,109,806)**	**(5,693,518)**	**(5,928,144)**	**(6,176,559)**	**(6,131,231)**	**(6,399,921)**	**(6,675,834)**	**(6,959,195)**	**(7,250,234)**	**(7,550,884)**	**(7,859,698)**	**(8,176,927)**	**(8,502,834)**	**(8,837,685)**	**(8,619,821)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	44,200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**59,970,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,262,103	5,484,941	5,720,692	5,970,231	5,883,349	6,101,340	6,326,554	6,559,215	6,799,555	7,047,812	7,304,233	7,569,070	7,842,583	8,125,042	8,416,721
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	764,400	787,332	810,952	835,281	860,339	886,149	912,734	940,116	968,319	997,369	1,027,290	1,058,108	1,089,852	1,122,547	1,156,224
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	12,410	12,782	13,166	13,561	13,968	14,387	14,818	15,263	15,721	16,192	16,678	17,178	17,694	18,225	18,771
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**7,362,841**	**7,665,526**	**7,984,025**	**8,319,315**	**8,321,291**	**8,631,357**	**8,951,977**	**9,283,491**	**9,626,252**	**9,980,625**	**10,346,983**	**10,725,714**	**11,117,218**	**11,521,904**	**11,940,198**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site		20,600	21,218	21,855	22,510	23,185	23,881	24,597	25,335	26,095	26,878	27,685	28,515	29,371	30,252
Total refurbishments	**0**	**341,960**	**352,219**	**362,785**	**373,669**	**384,879**	**396,425**	**408,318**	**420,568**	**433,185**	**446,180**	**459,566**	**473,353**	**487,553**	**502,180**
Net escalated benefit/(cost)	**(65,109,806)**	**(5,699,775)**	**(5,940,778)**	**(6,195,691)**	**(6,162,342)**	**(6,447,478)**	**(6,743,613)**	**(7,051,140)**	**(7,370,462)**	**(7,704,207)**	**(8,050,731)**	**(8,410,487)**	**(8,783,943)**	**(9,171,583)**	**(8,723,928)**
Life cycle cost analysis															
PVs in 2021	(65,109,806)	(5,588,015)	(5,710,091)	(5,838,338)	(5,693,052)	(5,839,679)	(5,988,135)	(6,138,441)	(6,290,618)	(6,446,536)	(6,604,404)	(6,764,244)	(6,926,079)	(7,089,932)	(6,611,647)
NPV as of 2021	**(265,310,149)**														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
2 Month Storage, Contract Haul, at Pinole

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Pinole															
Front Loader															
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,717,907	9,028,891	9,349,976	9,681,472	10,023,699	10,376,987	10,741,674	11,118,110	11,506,654	11,907,677	12,321,559	12,748,693	13,189,482	13,644,343	14,188,294
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400	764,400
Odor Control Chemicals	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410	12,410
Total running costs	11,063,676	11,390,995	11,728,416	12,076,247	12,434,810	12,804,433	13,185,455	13,578,227	13,983,106	14,400,464	14,830,682	15,274,151	15,731,276	16,202,472	16,762,759
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total refurbishments	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000	332,000
Net Benefit/(cost)	(8,921,575)	(9,233,129)	(9,554,782)	(9,886,847)	(10,229,135)	(10,582,991)	(10,948,247)	(11,325,252)	(11,714,365)	(12,115,956)	(12,565,972)	(13,045,499)	(13,538,682)	(14,011,617)	(14,573,642)

Expressed in escalated dollars with sensitivity adjustments

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,717,907	9,028,891	9,349,976	9,681,472	10,023,699	10,376,987	10,741,674	11,118,110	11,506,654	11,907,677	12,321,559	12,748,693	13,189,482	13,644,343	14,188,294
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	1,190,910	1,226,638	1,263,437	1,301,340	1,340,380	1,380,591	1,422,009	1,464,669	1,508,610	1,553,868	1,600,484	1,648,498	1,697,953	1,748,892	1,801,359
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	19,334	19,914	20,512	21,127	21,761	22,414	23,086	23,779	24,492	25,227	25,984	26,763	27,566	28,393	29,245
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	12,372,538	12,819,375	13,281,175	13,758,416	14,251,596	14,761,224	15,287,827	15,831,948	16,394,147	16,975,000	17,575,105	18,195,074	18,835,541	19,497,158	20,255,189
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site	31,159	32,094	33,057	34,049	35,070	36,122	37,206	38,322	39,472	40,656	41,876	43,132	44,426	45,759	47,131
Total refurbishments	517,245	532,763	548,745	565,208	582,164	599,629	617,618	636,146	655,231	674,888	695,134	715,988	737,468	759,592	782,380
Net escalated benefit/(cost)	(9,035,216)	(9,356,632)	(9,688,490)	(10,031,109)	(10,383,932)	(10,749,054)	(11,125,961)	(11,515,015)	(11,916,589)	(12,331,066)	(12,833,307)	(13,388,783)	(13,965,155)	(14,484,639)	(15,096,392)

Life cycle cost analysis

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PVs in 2021	(6,713,299)	(6,815,800)	(6,919,156)	(7,023,375)	(7,127,850)	(7,233,805)	(7,340,640)	(7,448,361)	(7,556,975)	(7,666,489)	(7,822,297)	(8,000,859)	(8,181,654)	(8,319,608)	(8,500,964)
NPV as of 2021	**(265,310,149)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
2 Month Storage, EBMUD Haul, at Pinole

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Pinole	44,200,000														
Front Loader	170,000														
Total capital outlays	**59,970,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,745,322	4,957,479	5,182,359	5,420,833	5,728,843	5,941,107	6,160,405	6,386,954	6,621,005	6,862,742	7,112,427	7,370,307	7,636,636	7,911,675	8,195,693
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**7,164,230**	**7,392,722**	**7,633,938**	**7,888,747**	**8,213,092**	**8,441,692**	**8,677,325**	**8,920,210**	**9,170,596**	**9,428,668**	**9,694,689**	**9,968,905**	**10,251,569**	**10,542,943**	**10,843,297**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site		20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total refurbishments	**0**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**
Net Benefit/(cost)	**(64,911,195)**	**(5,484,226)**	**(5,707,982)**	**(5,945,330)**	**(6,294,894)**	**(6,557,859)**	**(6,827,855)**	**(7,105,104)**	**(7,389,854)**	**(7,683,984)**	**(7,986,062)**	**(8,296,335)**	**(8,615,057)**	**(8,942,489)**	**(8,716,963)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	44,200,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**59,970,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,745,322	4,957,479	5,182,359	5,420,833	5,728,843	5,941,107	6,160,405	6,386,954	6,621,005	6,862,742	7,112,427	7,370,307	7,636,636	7,911,675	8,195,693
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	1,070,160	1,102,265	1,135,333	1,169,393	1,204,475	1,240,609	1,277,827	1,316,162	1,355,647	1,396,316	1,438,206	1,481,352	1,525,792	1,571,566	1,618,713
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	24,820	25,565	26,332	27,121	27,935	28,773	29,636	30,525	31,441	32,384	33,356	34,357	35,387	36,449	37,542
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**7,164,230**	**7,465,779**	**7,783,239**	**8,117,589**	**8,524,887**	**8,839,971**	**9,165,740**	**9,502,539**	**9,850,751**	**10,210,694**	**10,582,771**	**10,967,374**	**11,364,905**	**11,775,781**	**12,200,431**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site		20,600	21,218	21,855	22,510	23,185	23,881	24,597	25,335	26,095	26,878	27,685	28,515	29,371	30,252
Total refurbishments	**0**	**341,960**	**352,219**	**362,785**	**373,669**	**384,879**	**396,425**	**408,318**	**420,568**	**433,185**	**446,180**	**459,566**	**473,353**	**487,553**	**502,180**
Net escalated benefit/(cost)	**(64,911,195)**	**(5,500,029)**	**(5,739,992)**	**(5,993,966)**	**(6,365,939)**	**(6,656,091)**	**(6,957,376)**	**(7,270,188)**	**(7,594,960)**	**(7,934,276)**	**(8,286,519)**	**(8,652,146)**	**(9,031,630)**	**(9,425,460)**	**(8,984,161)**
Life cycle cost analysis															
PVs in 2021	(64,911,195)	(5,392,185)	(5,517,101)	(5,648,248)	(5,881,143)	(6,028,627)	(6,177,950)	(6,329,136)	(6,482,225)	(6,639,047)	(6,797,832)	(6,958,601)	(7,121,379)	(7,286,187)	(6,808,871)
NPV as of 2021	**(269,693,250)**														

From Summary Sheet:

Year of analysis	**2021**	**Benefits**	**0%**
Escalation rate	**3.00%**	**Capital costs**	**0%**
Discount rate	**2.00%**	**Running costs**	**0%**

Risk adjustments (+/- percent):

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
2 Month Storage, EBMUD Haul, at Pinole

Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)

	Year														
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Pinole															
Front Loader															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,488,968	8,791,783	9,104,434	9,427,223	9,760,460	10,104,468	10,459,575	10,826,123	11,204,496	11,594,985	11,997,996	12,413,911	12,843,123	13,286,036	13,743,068
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**11,152,907**	**11,472,058**	**11,801,044**	**12,140,168**	**12,489,741**	**12,850,084**	**13,221,527**	**13,604,410**	**13,999,118**	**14,405,943**	**14,825,289**	**15,257,539**	**15,703,086**	**16,162,335**	**16,635,703**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Total refurbishments	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**	**332,000**
Net Benefit/(cost)	**(9,010,806)**	**(9,314,191)**	**(9,627,410)**	**(9,950,768)**	**(10,284,066)**	**(10,628,642)**	**(10,984,319)**	**(11,351,435)**	**(11,730,377)**	**(12,121,435)**	**(12,560,580)**	**(13,028,888)**	**(13,510,492)**	**(13,971,480)**	**(14,446,586)**

Expressed in escalated dollars with sensitivity adjustments

	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	8,488,968	8,791,783	9,104,434	9,427,223	9,760,460	10,104,468	10,459,575	10,826,123	11,204,496	11,594,985	11,997,996	12,413,911	12,843,123	13,286,036	13,743,068
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	1,667,274	1,717,293	1,768,811	1,821,876	1,876,532	1,932,828	1,990,813	2,050,537	2,112,053	2,175,415	2,240,677	2,307,898	2,377,135	2,448,449	2,521,902
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	38,669	39,829	41,024	42,254	43,522	44,828	46,173	47,558	48,984	50,454	51,968	53,527	55,132	56,786	58,490
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**12,639,298**	**13,092,837**	**13,561,519**	**14,045,830**	**14,546,270**	**15,063,356**	**15,597,619**	**16,149,608**	**16,719,925**	**17,309,083**	**17,917,720**	**18,546,455**	**19,195,929**	**19,866,800**	**20,559,751**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site	31,159	32,094	33,057	34,049	35,070	36,122	37,206	38,322	39,472	40,656	41,876	43,132	44,426	45,759	47,131
Total refurbishments	**517,245**	**532,763**	**548,745**	**565,208**	**582,164**	**599,629**	**617,618**	**636,146**	**655,231**	**674,888**	**695,134**	**715,988**	**737,468**	**759,592**	**782,380**
Net escalated benefit/(cost)	**(9,301,975)**	**(9,630,094)**	**(9,968,834)**	**(10,318,523)**	**(10,678,606)**	**(11,051,185)**	**(11,435,752)**	**(11,832,675)**	**(12,242,367)**	**(12,665,149)**	**(13,175,922)**	**(13,740,164)**	**(14,325,543)**	**(14,854,282)**	**(15,400,954)**

Life cycle cost analysis

PVs in 2021	(6,911,505)	(7,015,002)	(7,119,368)	(7,224,611)	(7,330,124)	(7,437,131)	(7,545,033)	(7,653,836)	(7,763,570)	(7,874,195)	(8,031,131)	(8,210,838)	(8,392,792)	(8,531,921)	(8,672,467)
NPV as of 2021	**(269,693,250)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
4 Month Storage at Pinole

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Pinole	80,500,000														
Front Loader	170,000														
Total capital outlays	**96,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,364,816	4,508,281	4,658,644	4,816,353	5,048,690	5,235,755	5,429,018	5,628,672	5,834,915	6,047,953	6,267,996	6,495,260	6,729,971	6,972,358	7,222,657
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**6,783,724**	**6,943,524**	**7,110,222**	**7,284,267**	**7,532,939**	**7,736,340**	**7,945,938**	**8,161,928**	**8,384,506**	**8,613,879**	**8,850,257**	**9,093,858**	**9,344,904**	**9,603,626**	**9,870,261**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site		40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Total refurbishments	**0**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**
Net Benefit/(cost)	**(100,830,688)**	**(5,055,028)**	**(5,204,266)**	**(5,360,850)**	**(5,634,742)**	**(5,872,506)**	**(6,116,468)**	**(6,366,822)**	**(6,623,764)**	**(6,889,195)**	**(7,161,630)**	**(7,441,288)**	**(7,728,392)**	**(8,023,171)**	**(7,763,927)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	80,500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**96,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	4,364,816	4,508,281	4,658,644	4,816,353	5,048,690	5,235,755	5,429,018	5,628,672	5,834,915	6,047,953	6,267,996	6,495,260	6,729,971	6,972,358	7,222,657
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	1,070,160	1,102,265	1,135,333	1,169,393	1,204,475	1,240,609	1,277,827	1,316,162	1,355,647	1,396,316	1,438,206	1,481,352	1,525,792	1,571,566	1,618,713
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	24,820	25,565	26,332	27,121	27,935	28,773	29,636	30,525	31,441	32,384	33,356	34,357	35,387	36,449	37,542
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**6,783,724**	**7,016,582**	**7,259,524**	**7,513,109**	**7,844,735**	**8,134,618**	**8,434,353**	**8,744,257**	**9,064,661**	**9,395,905**	**9,738,340**	**10,092,327**	**10,458,240**	**10,836,464**	**11,227,395**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site		41,200	42,436	43,709	45,020	46,371	47,762	49,195	50,671	52,191	53,757	55,369	57,030	58,741	60,504
Total refurbishments	**0**	**362,560**	**373,437**	**384,640**	**396,179**	**408,064**	**420,306**	**432,916**	**445,903**	**459,280**	**473,059**	**487,250**	**501,868**	**516,924**	**532,432**
Net escalated benefit/(cost)	**(100,830,688)**	**(5,071,431)**	**(5,237,495)**	**(5,411,340)**	**(5,708,296)**	**(5,973,924)**	**(6,249,870)**	**(6,536,503)**	**(6,834,206)**	**(7,145,583)**	**(7,468,966)**	**(7,804,784)**	**(8,153,480)**	**(8,515,513)**	**(8,041,377)**
Life cycle cost analysis															
PVs in 2021	(100,830,688)	(4,971,991)	(5,034,117)	(5,099,227)	(5,273,583)	(5,410,767)	(5,549,705)	(5,690,419)	(5,832,929)	(5,979,104)	(6,127,154)	(6,277,099)	(6,428,963)	(6,582,768)	(6,094,359)
NPV as of 2021	**(284,885,660)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
4 Month Storage at Pinole

Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Pinole															
Front Loader															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,481,114	7,747,980	8,023,513	8,307,980	8,601,656	8,904,824	9,217,774	9,540,805	9,874,227	10,218,358	10,573,523	10,940,060	11,318,316	11,708,647	12,292,569
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160	1,070,160
Odor Control Chemicals	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820	24,820
Total running costs	**10,145,053**	**10,428,254**	**10,720,123**	**11,020,926**	**11,330,937**	**11,650,440**	**11,979,725**	**12,319,092**	**12,668,849**	**13,029,315**	**13,400,816**	**13,783,688**	**14,178,279**	**14,584,946**	**15,185,203**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pinole site	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Total refurbishments	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**	**352,000**
Net Benefit/(cost)	**(8,022,953)**	**(8,290,387)**	**(8,566,489)**	**(8,851,525)**	**(9,145,262)**	**(9,448,998)**	**(9,762,517)**	**(10,086,117)**	**(10,420,108)**	**(10,764,807)**	**(11,156,107)**	**(11,575,037)**	**(12,005,685)**	**(12,414,090)**	**(13,016,086)**

Expressed in escalated dollars with sensitivity adjustments

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,481,114	7,747,980	8,023,513	8,307,980	8,601,656	8,904,824	9,217,774	9,540,805	9,874,227	10,218,358	10,573,523	10,940,060	11,318,316	11,708,647	12,292,569
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	1,667,274	1,717,293	1,768,811	1,821,876	1,876,532	1,932,828	1,990,813	2,050,537	2,112,053	2,175,415	2,240,677	2,307,898	2,377,135	2,448,449	2,521,902
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	38,669	39,829	41,024	42,254	43,522	44,828	46,173	47,558	48,984	50,454	51,968	53,527	55,132	56,786	58,490
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**11,631,444**	**12,049,033**	**12,480,598**	**12,926,588**	**13,387,466**	**13,863,712**	**14,355,817**	**14,864,290**	**15,389,656**	**15,932,456**	**16,493,247**	**17,072,604**	**17,671,122**	**18,289,411**	**19,109,251**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinole site	62,319	64,188	66,114	68,097	70,140	72,244	74,412	76,644	78,943	81,312	83,751	86,264	88,852	91,517	94,263
Total refurbishments	**548,405**	**564,857**	**581,802**	**599,256**	**617,234**	**635,751**	**654,824**	**674,468**	**694,702**	**715,544**	**737,010**	**759,120**	**781,894**	**805,351**	**829,511**
Net escalated benefit/(cost)	**(8,325,281)**	**(8,618,385)**	**(8,920,970)**	**(9,233,329)**	**(9,554,872)**	**(9,887,663)**	**(10,231,156)**	**(10,585,679)**	**(10,951,570)**	**(11,329,177)**	**(11,793,324)**	**(12,309,445)**	**(12,845,162)**	**(13,322,651)**	**(13,997,586)**

Life cycle cost analysis

	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
PVs in 2021	(6,185,807)	(6,278,026)	(6,371,023)	(6,464,802)	(6,558,758)	(6,654,114)	(6,750,269)	(6,847,231)	(6,945,003)	(7,043,593)	(7,188,395)	(7,355,870)	(7,525,493)	(7,652,191)	(7,882,213)
NPV as of 2021	**(284,885,660)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
6 Month Storage, at Pinole

	Year														
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Pinole	111,500,000														
Front Loader	170,000														
Total capital outlays	**127,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	**2,223,036**	**2,240,496**	**2,257,956**	**2,275,416**	**2,250,198**	**2,215,834**	**2,181,470**	**2,147,106**	**2,112,742**	**2,076,685**	**2,040,627**	**2,004,570**	**1,968,512**	**1,932,455**	**2,458,334**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,696,357	6,016,809	6,358,311	6,722,311	5,254,600	5,449,295	5,650,440	5,858,237	6,072,892	6,294,618	6,523,635	6,760,169	7,004,452	7,256,724	7,517,233
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Odor Control Chemicals	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
Total running costs	**8,586,314**	**8,923,102**	**9,280,939**	**9,661,275**	**8,209,900**	**8,420,930**	**8,638,410**	**8,862,542**	**9,093,533**	**9,331,595**	**9,576,947**	**9,829,816**	**10,090,435**	**10,359,043**	**10,635,886**
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pionle site		60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Total refurbishments	**0**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**
Net Benefit/(cost)	**(133,633,279)**	**(7,054,606)**	**(7,394,983)**	**(7,757,859)**	**(6,331,702)**	**(6,577,096)**	**(6,828,940)**	**(7,087,436)**	**(7,352,791)**	**(7,626,910)**	**(7,908,320)**	**(8,197,247)**	**(8,493,923)**	**(8,798,588)**	**(8,549,553)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	111,500,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**127,270,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**2,223,036**	**2,307,711**	**2,395,466**	**2,486,409**	**2,532,617**	**2,568,759**	**2,604,789**	**2,640,670**	**2,676,359**	**2,709,602**	**2,742,432**	**2,774,793**	**2,806,628**	**2,837,875**	**3,718,450**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,696,357	6,016,809	6,358,311	6,722,311	5,254,600	5,449,295	5,650,440	5,858,237	6,072,892	6,294,618	6,523,635	6,760,169	7,004,452	7,256,724	7,517,233
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	37,230	38,347	39,497	40,682	41,903	43,160	44,455	45,788	47,162	48,577	50,034	51,535	53,081	54,674	56,314
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**8,586,314**	**9,010,291**	**9,458,928**	**9,933,796**	**8,580,816**	**8,894,234**	**9,218,233**	**9,553,154**	**9,899,349**	**10,257,184**	**10,627,031**	**11,009,279**	**11,404,326**	**11,812,583**	**12,234,476**
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pionle site		61,800	63,654	65,564	67,531	69,556	71,643	73,792	76,006	78,286	80,635	83,054	85,546	88,112	90,755
Total refurbishments	**0**	**383,160**	**394,655**	**406,494**	**418,689**	**431,250**	**444,187**	**457,513**	**471,238**	**485,376**	**499,937**	**514,935**	**530,383**	**546,295**	**562,683**
Net escalated benefit/(cost)	**(133,633,279)**	**(7,085,740)**	**(7,458,117)**	**(7,853,882)**	**(6,466,888)**	**(6,756,725)**	**(7,057,631)**	**(7,369,997)**	**(7,694,229)**	**(8,032,957)**	**(8,384,536)**	**(8,749,421)**	**(9,128,081)**	**(9,521,003)**	**(9,078,709)**
Life cycle cost analysis															
PVs in 2021	(133,633,279)	(6,946,804)	(7,168,509)	(7,400,888)	(5,974,405)	(6,119,774)	(6,266,974)	(6,416,026)	(6,566,951)	(6,721,619)	(6,878,240)	(7,036,836)	(7,197,430)	(7,360,045)	(6,880,527)
NPV as of 2021	**(345,239,062)**														

From Summary Sheet:

Year of analysis	**2021**	**Benefits**	**0%**
Escalation rate	**3.00%**	**Capital costs**	**0%**
Discount rate	**2.00%**	**Running costs**	**0%**

Risk adjustments (+/- percent):

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
6 Month Storage, at Pinole

	Year														
	2036	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**	**2047**	**2048**	**2049**	**2050**
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Pinole															
Front Loader															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,786,231	8,063,980	8,350,751	8,646,821	8,952,474	9,268,006	9,593,719	9,929,926	10,276,947	10,635,112	11,004,763	11,386,249	11,779,932	12,186,183	12,877,106
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Odor Control Chemicals	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
Total running costs	**10,921,220**	**11,215,305**	**11,518,411**	**11,830,816**	**12,152,805**	**12,484,672**	**12,826,721**	**13,179,263**	**13,542,619**	**13,917,120**	**14,303,106**	**14,700,928**	**15,110,946**	**15,533,532**	**16,240,791**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Pionle site	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Total refurbishments	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**
Net Benefit/(cost)	**(8,819,119)**	**(9,097,438)**	**(9,384,777)**	**(9,681,416)**	**(9,987,130)**	**(10,303,231)**	**(10,629,513)**	**(10,966,288)**	**(11,313,877)**	**(11,672,612)**	**(12,078,397)**	**(12,512,276)**	**(12,958,352)**	**(13,382,676)**	**(14,091,674)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Pinole	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,786,231	8,063,980	8,350,751	8,646,821	8,952,474	9,268,006	9,593,719	9,929,926	10,276,947	10,635,112	11,004,763	11,386,249	11,779,932	12,186,183	12,877,106
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	58,003	59,743	61,536	63,382	65,283	67,242	69,259	71,337	73,477	75,681	77,951	80,290	82,699	85,180	87,735
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**12,670,441**	**13,120,931**	**13,586,410**	**14,067,359**	**14,564,273**	**15,077,663**	**15,608,054**	**16,155,991**	**16,722,033**	**17,306,758**	**17,910,761**	**18,534,656**	**19,179,076**	**19,844,675**	**20,803,849**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pionle site	93,478	96,282	99,171	102,146	105,210	108,367	111,618	114,966	118,415	121,968	125,627	129,395	133,277	137,276	141,394
Total refurbishments	**579,564**	**596,951**	**614,859**	**633,305**	**652,304**	**671,873**	**692,030**	**712,790**	**734,174**	**756,199**	**778,885**	**802,252**	**826,320**	**851,109**	**876,642**
Net escalated benefit/(cost)	**(9,395,438)**	**(9,722,376)**	**(10,059,839)**	**(10,408,149)**	**(10,766,749)**	**(11,137,737)**	**(11,520,600)**	**(11,915,703)**	**(12,323,419)**	**(12,744,135)**	**(13,252,714)**	**(13,814,629)**	**(14,397,543)**	**(14,923,673)**	**(15,739,314)**
Life cycle cost analysis															
PVs in 2021	(6,980,949)	(7,082,224)	(7,184,360)	(7,287,363)	(7,390,628)	(7,495,377)	(7,601,013)	(7,707,542)	(7,814,969)	(7,923,303)	(8,077,938)	(8,255,336)	(8,434,974)	(8,571,778)	(8,863,002)
NPV as of 2021	**(345,239,062)**														

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
6 Month Storage, at Merced

	Year														
	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Expressed in 2021 dollars, unescalated															
Capital Outlays															
Screening	15,600,000														
Treatment/Storage Facility															
Storage at Merced	110,400,000														
Front Loader	170,000														
Total capital outlays	126,170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
Energy Offset	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Total benefits	2,223,036	2,240,496	2,257,956	2,275,416	2,250,198	2,215,834	2,181,470	2,147,106	2,112,742	2,076,685	2,040,627	2,004,570	1,968,512	1,932,455	2,458,334
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,696,357	6,016,809	6,358,311	6,722,311	4,858,619	5,038,641	5,224,629	5,416,766	5,615,245	5,820,262	6,032,021	6,250,729	6,476,604	6,709,865	6,950,742
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,340,263	1,356,599	1,372,934	1,389,269	1,405,605	1,421,940	1,438,276	1,454,611	1,470,947	1,487,282	1,503,617	1,519,953	1,536,288	1,552,624
Offsite Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Odor Control Chemicals	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
Total running costs	8,586,314	8,923,102	9,280,939	9,661,275	7,813,918	8,010,276	8,212,599	8,421,072	8,635,886	8,857,239	9,085,333	9,320,377	9,562,586	9,812,183	10,069,395
R&R Costs:															
Screening		312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Merced site		60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Total refurbishments	0	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000	372,000
Net Benefit/(cost)	(132,533,279)	(7,054,606)	(7,394,983)	(7,757,859)	(5,935,721)	(6,166,442)	(6,403,129)	(6,645,966)	(6,895,144)	(7,152,554)	(7,416,705)	(7,687,807)	(7,966,074)	(8,251,729)	(7,983,062)
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	15,600,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Merced	110,400,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	126,170,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	2,223,036	2,307,711	2,395,466	2,486,409	2,532,617	2,568,759	2,604,789	2,640,670	2,676,359	2,709,602	2,742,432	2,774,793	2,806,628	2,837,875	3,718,450
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	5,696,357	6,016,809	6,358,311	6,722,311	4,858,619	5,038,641	5,224,629	5,416,766	5,615,245	5,820,262	6,032,021	6,250,729	6,476,604	6,709,865	6,950,742
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,323,928	1,380,471	1,439,216	1,500,242	1,563,635	1,629,481	1,697,871	1,768,898	1,842,658	1,919,252	1,998,783	2,081,358	2,167,089	2,256,091	2,348,482
Offsite Labor	1,528,800	1,574,664	1,621,904	1,670,561	1,720,678	1,772,298	1,825,467	1,880,231	1,936,638	1,994,737	2,054,579	2,116,217	2,179,703	2,245,094	2,312,447
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	37,230	38,347	39,497	40,682	41,903	43,160	44,455	45,788	47,162	48,577	50,034	51,535	53,081	54,674	56,314
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	8,586,314	9,010,291	9,458,928	9,933,796	8,184,834	8,483,581	8,792,421	9,111,683	9,441,703	9,782,828	10,135,416	10,499,839	10,876,477	11,265,724	11,667,985
R&R Costs:															
Screening	0	321,360	331,001	340,931	351,159	361,694	372,544	383,721	395,232	407,089	419,302	431,881	444,837	458,183	471,928
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merced site		61,800	63,654	65,564	67,531	69,556	71,643	73,792	76,006	78,286	80,635	83,054	85,546	88,112	90,755
Total refurbishments	0	383,160	394,655	406,494	418,689	431,250	444,187	457,513	471,238	485,376	499,937	514,935	530,383	546,295	562,683
Net escalated benefit/(cost)	(132,533,279)	(7,085,740)	(7,458,117)	(7,853,882)	(6,070,906)	(6,346,072)	(6,631,820)	(6,928,526)	(7,236,582)	(7,558,601)	(7,892,921)	(8,239,981)	(8,600,233)	(8,974,144)	(8,512,218)
Life cycle cost analysis															
PVs in 2021	(132,533,279)	(6,946,804)	(7,168,509)	(7,400,888)	(5,608,579)	(5,747,833)	(5,888,866)	(6,031,699)	(6,176,353)	(6,324,699)	(6,474,944)	(6,627,112)	(6,781,225)	(6,937,305)	(6,451,198)
NPV as of 2021	(332,501,463)														

East Bay Municipal Utility District
MWWTP Master Plan
Life Cycle Alternative Cost Analysis
6 Month Storage, at Merced

From Summary Sheet:		Risk adjustments (+/- percent):	
Year of analysis	2021	Benefits	0%
Escalation rate	3.00%	Capital costs	0%
Discount rate	2.00%	Running costs	0%

	Year														
	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Expressed in 2021 dollars, unescalated (continuation see previous sheet for years 2021 through 2035)															
Capital Outlays															
Screening															
Treatment/Storage Facility															
Storage at Merced															
Front Loader															
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
Energy Offset	2,474,100	2,489,867	2,505,634	2,521,400	2,537,675	2,553,442	2,569,208	2,584,975	2,600,741	2,616,508	2,596,709	2,560,652	2,524,594	2,522,855	2,521,117
Total benefits	**2,474,100**	**2,489,867**	**2,505,634**	**2,521,400**	**2,537,675**	**2,553,442**	**2,569,208**	**2,584,975**	**2,600,741**	**2,616,508**	**2,596,709**	**2,560,652**	**2,524,594**	**2,522,855**	**2,521,117**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,199,468	7,456,287	7,721,447	7,995,205	8,277,825	8,569,579	8,870,747	9,181,617	9,502,486	9,833,661	10,175,455	10,528,193	10,892,208	11,267,844	11,927,177
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	1,568,959	1,585,294	1,601,630	1,617,965	1,634,301	1,650,636	1,666,971	1,683,307	1,699,642	1,715,978	1,732,313	1,748,648	1,764,984	1,781,319	1,797,655
Offsite Labor	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800	1,528,800
Odor Control Chemicals	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230	37,230
Total running costs	**10,334,457**	**10,607,611**	**10,889,107**	**11,179,200**	**11,478,155**	**11,786,245**	**12,103,748**	**12,430,954**	**12,768,159**	**13,115,669**	**13,473,798**	**13,842,872**	**14,223,222**	**14,615,193**	**15,290,862**
R&R Costs:															
Screening	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000	312,000
Merced site	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Total refurbishments	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**	**372,000**
Net Benefit/(cost)	**(8,232,357)**	**(8,489,744)**	**(8,755,473)**	**(9,029,800)**	**(9,312,480)**	**(9,604,803)**	**(9,906,540)**	**(10,217,979)**	**(10,539,417)**	**(10,871,160)**	**(11,249,089)**	**(11,654,220)**	**(12,070,628)**	**(12,464,338)**	**(13,141,745)**
Expressed in escalated dollars with sensitivity adjustments															
Capital Outlays															
Screening	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Treatment/Storage Facility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Storage at Merced	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Front Loader	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total capital outlays	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Benefits:															
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Energy Offset	3,854,568	3,995,505	4,141,430	4,292,515	4,449,828	4,611,799	4,779,484	4,953,079	5,132,788	5,318,822	5,436,932	5,522,279	5,607,853	5,772,111	5,941,177
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total benefits	**3,854,568**	**3,995,505**	**4,141,430**	**4,292,515**	**4,449,828**	**4,611,799**	**4,779,484**	**4,953,079**	**5,132,788**	**5,318,822**	**5,436,932**	**5,522,279**	**5,607,853**	**5,772,111**	**5,941,177**
Annual Running Costs:															
Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Biosolids Disposition	7,199,468	7,456,287	7,721,447	7,995,205	8,277,825	8,569,579	8,870,747	9,181,617	9,502,486	9,833,661	10,175,455	10,528,193	10,892,208	11,267,844	11,927,177
Natural Gas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals- at EBMUD	2,444,387	2,543,932	2,647,250	2,754,477	2,865,756	2,981,232	3,101,058	3,225,390	3,354,391	3,488,229	3,627,079	3,771,120	3,920,539	4,075,529	4,236,291
Offsite Labor	2,381,821	2,453,275	2,526,873	2,602,680	2,680,760	2,761,183	2,844,018	2,929,339	3,017,219	3,107,736	3,200,968	3,296,997	3,395,907	3,497,784	3,602,717
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Odor Control Chemicals	58,003	59,743	61,536	63,382	65,283	67,242	69,259	71,337	73,477	75,681	77,951	80,290	82,699	85,180	87,735
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total running costs	**12,083,679**	**12,513,237**	**12,957,106**	**13,415,743**	**13,889,624**	**14,379,235**	**14,885,081**	**15,407,682**	**15,947,573**	**16,505,307**	**17,081,453**	**17,676,600**	**18,291,353**	**18,926,337**	**19,853,920**
R&R Costs:															
Screening	486,086	500,668	515,688	531,159	547,094	563,507	580,412	597,824	615,759	634,232	653,259	672,856	693,042	713,833	735,248
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Merced site	93,478	96,282	99,171	102,146	105,210	108,367	111,618	114,966	118,415	121,968	125,627	129,395	133,277	137,276	141,394
Total refurbishments	**579,564**	**596,951**	**614,859**	**633,305**	**652,304**	**671,873**	**692,030**	**712,790**	**734,174**	**756,199**	**778,885**	**802,252**	**826,320**	**851,109**	**876,642**
Net escalated benefit/(cost)	**(8,808,675)**	**(9,114,683)**	**(9,430,535)**	**(9,756,534)**	**(10,092,100)**	**(10,439,309)**	**(10,797,627)**	**(11,167,393)**	**(11,548,959)**	**(11,942,684)**	**(12,423,406)**	**(12,956,572)**	**(13,509,819)**	**(14,005,335)**	**(14,789,386)**
Life cycle cost analysis															
PVs in 2021	(6,544,975)	(6,639,553)	(6,734,935)	(6,831,128)	(6,927,528)	(7,025,356)	(7,124,013)	(7,223,506)	(7,323,841)	(7,425,023)	(7,572,449)	(7,742,579)	(7,914,890)	(8,044,308)	(8,328,085)
NPV as of 2021	**(332,501,463)**														

Budget Proposal
ANDRITZ Biosolids Drum Drying System (DDS)
East Bay Municipal Utility District, CA Masterplan

Budget Proposal No. 3325629-1 rev.0

Provided to:	**Brown & Caldwell**
	1 Tech Drive #310
	Andover, MA 01810
Attention:	Tracy Chouinard, PhD, PE*
	tchouinard@brwncald.com
	T 978.983.2047
Date Issued	April 21, 2019
Issued by:	Peter Commerford

ANDRITZ Drum Drying System model DDS-120 Philadelphia, PA

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April 4, 2020 Sent via email to: :tchouinard@brwncald.com

Brown & Caldwell
1 Tech Drive #310
Andover, MA 01810

ATTENTION: Tracy Chouinard, PhD, PE*
T 978.983.2047

SUBJECT: East Bay MUD Masterplan Biosolids Drying
ANDRITZ Drum Drying System (DDS)
ANDRITZ Budgetary Information # 2708688-2 rev. 1

Dear Tracy:

In response to your request dated May 31, 2020, we are pleased to provide you with our Budget Proposal and information to support your Masterplan efforts and the assessment of residuals management via Class A Biosolids Drying for EBMUD. The enclosed Dryer Selections break down as follows:

	2020 Avg. Day	2020 Max. Day	2030 Avg. Day	2030 Max. Day	2050 Avg. Day	2050 Max. Day
Sludge Production (lbs/day DS)	119,143	214,457	133,102	239,583	166,143	299,057
Sludge Production (dry tons/year)	21,744	39,138	24,291	43,724	30,321	54,578
Cake dryness	24% DS	24% DS	24% DS	24% DS	24% DS	24% DS
Dryer Operations (days/week)	7	7	7	7	7	7
Hours of Operation (hours/day	24	24	24	24	24	24
Dryer Cake feed (wet lbs/h)	20,685	37,232	23,108	41,594	28,844	51,920
Final Product	95% DS	95% DS	95% DS	95% DS	95% DS	95% DS
Final Product (wet lbs/hour)	5,226	9,406	5,838	10,508	7,287	13,117
Evaporation Rate (lbs/h H2O)	15,459	27,826	17,270	31,086	21,557	38,803
Evaporation Rate (kg/h H2O)	7,011	12,620	7,832	14,098	9,777	17,598
No. of Drying Trains	2	2	2	2	3	3
Trains in Operation	1+1 standby	2	1+1 standby	2	2+1 standby	2+1 standby
Fluid Bed Dryer Model	DDS-80	DDS-80	DDS-80	DDS-80	DDS-100	DDS-100
Max. Evap. Rate (kg/hH2O)	8,000	8,000	8,000	8,000	10,000	10,000
Alternate Sizing:						
Dryer Operations (days/week)	5	5	6	6	7	7
Evaporation Rate (kg/hH2O)	9,815	17,667	9,138	16,448	9,777	17,598
No. of Drying Trains	2	2	2	2	2	2
Trains in Operation	1+1 standby	2	1+1 standby	2	1+1 standby	2
Fluid Bed Dryer Model	DDS-100	DDS-100	DDS-100	DDS-100	DDS-100	DDS-100
Max. Evap. Rate (kg/hH2O)/train	10,000	10,000	10,000	10,000	10,000	10,000

For the purposes of this evaluation, we are providing within Budget information for 2 x DDS-100 Drum Drying Systems to satisfy the projected requirements through the year 2050. For all the average day cases one drying train will be operating with one drying train on stand-by.

Scope Outline:

Two (2) lines ANDRITZ Drum Drying System, includes (1) wet cake hopper & feed system, furnace, air pollution control equipment, biosolids cooling and biosolids transport system to storage silos.

- Wet cake feed bin after dewatering, with live bottom feeder & cake pumps
- ANDRITZ DDS 100 Drum Drying System
- Burner & furnace – Dual Fuel with digester gas and 100% natural gas low NO_x fuel trains
- Condenser and Venturi Scrubber package
- Full Backmix Technology with final Product Screen, Crusher and Cooler
- Interconnecting ductwork & Insulation of Andritz Dryer equipment.
- Controls & Instrumentation including PLC, MCC, VFD and HMI
- Emissions and Odor Control equipment (RTO) with fan (including stack)
- Pneumatic dense phase dry product transporter system with air compressor, boosters, receiver tank and air dryer
- Final product handling & (2) ea. 200 ton storage silos, each with associated dust collection from silos and load-out spout, N2 storage tank, vaporizer and controls
- Pellet Oiling System
- Structural steel supports ladders, access platforms and stairs
- Delivery to project jobsite.
- Field supervision of dryer equipment erection, startup, commissioning and Operations personnel training.

ANDRITZ Scope excludes;

- Mechanical and Electrical Installation
- Piping, process and utility, valves, etc.
- Civil, foundations, building,
- Electrical and process connections and ring-out.
- Cake Intake and Storage

The General Arrangement Drawings included within are from the larger 2 x DDS-120 project delivered in 2011 to Philadelphia, PA

ANDRITZ DDS – the industry standard for granules - provides Reuse options in Agriculture and as a Fuel

I will be pleased to discuss your project and this ANDRITZ budget information package at your convenience.

Thank you for this opportunity and for your interest in ANDRITZ products and services.

Sincerely,

Peter Commerford

Manager, Drying Systems
Mobile: (817) 271-2855

ANDRITZ Separation Technologies Inc.
1010 Commercial Blvd S.
Arlington, TX 76001 USA
Email: peter.commerford@andritz.com

Encl.: ANDRITZ Budget Information # 3325629-1 rev.0

1. DRUM DRYING SYSTEM (DDS) EXECUTIVE SUMMARY

- The ANDRITZ DDS drum drying technology has been successfully implemented in 22 installations in the United States for a total of 34 process trains.
- The bulk of our Arlington, TX team has been together since installing the first plant in Waco, TX and with the completion of Philadelphia, PA and Irvine Ranch, CA, we will now have installed & commissioned 35 dryers in the USA of the 147 biosolids dryer systems built around the world since 1974.
- The success of the ANDRITZ DDS system is combination of people behind the design as well as delivering a marketable product typically accepted by the end users as well as the community that produces the product. The DDS system produces a near dustless hardened spherical pellet with a normal size range of 0.5 – 4 mm in diameter.
- Dried pellets allow for the slow release of nitrogen and phosphorous into the soil maximizing uptake in agricultural plants. The ANDRITZ system produces the quality of pellets that are supported by this study and represent best practices for an environmental solution for biosolids management.
- The Manatee County project, featuring a Drum Drying System fueled by landfill gas, was delivered in its entirety by The ANDRITZ team under a Design & Build Contract with the County – it serves three (3) WWTP's with cake reception included.

Manatee County, Florida (DDS60 – landfill gas)

2. OVERVIEW - DRYER FACILITY SIZING AND DATA

2.1 DRYING SYSTEM SIZING AND ESTIMATED UTILITIES

	2020 Avg. Day	2020 Max. Day	2030 Avg. Day	2030 Max. Day	2050 Avg. Day	2050 Max. Day
Sludge Production (lbs/day DS)	119,143	214,457	133,102	239,583	166,143	299,057
Sludge Production (dry tons/year)	21,744	39,138	24,291	43,724	30,321	54,578
Cake dryness	24% DS	24% DS	24% DS	24% DS	24% DS	24% DS
Dryer Operations (days/week)	7	7	7	7	7	7
Hours of Operation (hours/day	24	24	24	24	24	24
Dryer Cake feed (wet lbs/h)	20,685	37,232	23,108	41,594	28,844	51,920
Final Product	95% DS	95% DS	95% DS	95% DS	95% DS	95% DS
Final Product (wet lbs/hour)	5,226	9,406	5,838	10,508	7,287	13,117
Evaporation Rate (lbs/h H2O)	15,459	27,826	17,270	31,086	21,557	38,803
Evaporation Rate (kg/h H2O)	7,011	12,620	7,832	14,098	9,777	17,598
No. of Drying Trains	2	2	2	2	3	3
Trains in Operation	1+1 standby	2	1+1 standby	2	2+1 standby	2+1 standby
Fluid Bed Dryer Model	DDS-80	DDS-80	DDS-80	DDS-80	DDS-100	DDS-100
Max. Evaporation Rate (kg/hH2O)	8,000	8,000	8,000	8,000	10,000	10,000
Alternate sizing						
Dryer Operations (days/week)	5	5	6	6	7	7
Evaporation Rate (kg/hH2O)	9,815	17,667	9,138	16,448	9,777	17,598
No. of Drying Trains	2	2	2	2	2	2
Trains in Operation	1+1 standby	2	1+1 standby	2	1+1 standby	2
Fluid Bed Dryer Model	DDS-100	DDS-100	DDS-100	DDS-100	DDS-100	DDS-100
Max. Evaporation Rate (kg/hH2O)	10,000	10,000	10,000	10,000	10,000	10,000
Operating Hours/year	6,240		7,488		8,736	
Heat Energy at 1,500 BTU/lb	32 MM BTU/h		30 MM BTU/h		32 MM BTU/h	
Annual Heat Energy (MM BTU)	202,574		226,308		282,487	
Electrical Energy (kWh/h)	650		650		650	
Annual Electrical (kWh)	4,056,000		4,867,200		5,678,400	
NPW consumption (USGPM)	750		750		750	
PW consumption	40		40		40	
Centrifuge Process Rate (lb/h DS)	6,950	12,510	6,470	11,646	6,923	12,461
Feed Consistency (assumption)	2.5% DS	2.5% DS	2.5% DS	2.5% DS	2.5% DS	2.5% DS
Centrifuge Process Rate (USGPM)	556	1,000	517	931	553	996
Centrifuge Selection	D7LL	D7LL	D7LL	D7LL	D7LL	D7LL
Capacity per Centrifuge (USGPM)	300	300	300	300	300	300
Centrifuge Selection	2+2 standby	3+1 standby	2+2 standby	3+1 standby	2+2 standby	3+1 standby

Optional centrifuges

Notes: Heat Energy includes RTO

Electrical Consumption excludes Centrifuge Dewatering

Operating Personnel 2/shift for integrated dewatering and drying

Maintenance Costs 1.5 - 2% of Dryer Capital Equipment Cost

2.2 NOTES ON SITING AND DEWATERING INTEGRATION

Based on the restrictions on available space on site, the purchase/ownership of adjacent land, and the proximity to the highways, it may be prudent to plan for integration of the dewatering and drying facility and the piping of liquid sludge under the surrounding roadways.

ANDRITZ Integrated Biosolids Dewatering and Drying, Central WWTP, Nashville, TN

An Example of a similar integrated facility is at Nashville, TN, whereby ANDRITZ supplied 2 x DDS-80 drying trains with two (2) D7LL thickening centrifuges and three (3) D&LL dewatering centrifuges.

The table in section 2.1 suggests the installation of four (4) D7LL dewatering centrifuges, with space allocated for a fifth machine in the future.

The additional footprint is minimal as the Centrifuges can be installed on an elevated mezzanine structure.

ANDRITZ D6LX, Regina, Saskatchewan

ANDRITZ Integrated Biosolids Dewatering and Drum Drying, Sacramento, CA

3. BUDGET PRICING

3.1 DRUM DRYING SYSTEM

All non-binding prices are shown in U.S. Dollars.

One (1)	ANDRITZ Drum Drying System Equipment Package	Included
Two (2)	200 ton dia. Drive Through Product Storage Silos skirted to the ground complete c/w with instrumentation, Nitrogen Inerting system, Truck loading spouts and dust control	Included
1 Lot	Support steelwork, service platforms, guardrails, and Structural Steel, Access walkways for Andritz scope	Included
1 Lot	Associated process ductwork	Included
1 Lot	Insulation and cladding of ANDRITZ equipment only	Included
1 Lot	All instruments, motors & MCC's for supplied equipment, PLC's and operator interface implementation	Included
1 lot	Engineering Services including: (a) Installation supervision 30 days (b) Field testing after completion of installation (c) Start-up (d) Performance testing (e) Training (f) O&M Manuals	Included
2 sets	Submittal Data in accordance with attached Drawings and Data Requirements	Included
1 Set	Final O&M Manuals (two (2) CD sets)	Included
1 Lot	Freight Charges for Delivery DAP to East Bay MUD job-site (INCOTERMS 2010)	Included

Two (2) ANDRITZ DRUM DRYING SYSTEM DDS-100 .... $24,938,000

Terms and Conditions

This BUDGET Proposal is based on acceptance of the ANDRITZ Separation Inc. "Standard Terms and Conditions of Sale" (attached).

Special Information

The quoted price in this proposal has been calculated based on the current market prices required to manufacture the quoted equipment and services pursuant to regulations, duties and law in effect as of the date of this proposal. The quoted price shall remain firm for a period of thirty (30) days, except and subject to the following. In the event that the introduction of new tariffs, levies, duties, regulations, or any type of legislation by a domestic or foreign government has the effect of increasing the price of the quoted equipment or services, Andritz reserves its right to adjust its quoted price in order to reflect these increases in cost. Nothing in this document, or in any of the applicable contractual documentation shall be construed as a waiver of this right.

- This document is for information & budgetary purpose only and is not valid for tender.
- No specifications were provided to Andritz for this budget information.
- All prices are listed as US Dollars.
- Prices do not include any local or federal fees or taxes, permits or other fees. Any taxes or fees that may apply or come into effect after this offer must be added to the quoted price and paid by the Buyer.
- This Budgetary information is based on current commodity prices & currency exchange rates and is subject to adjustment at time of order entry & acceptance by Andritz.
- This Budgetary information is based upon known present safety codes and protection requirements for this type of equipment. Any changes between now and date of an actual order may require adjustments for codes and safety requirements in place at that point in time.
- Bid Bond, Payment Bond nor Performance Bond are not included.
- Above scope and budget price excludes dewatering equipment (centrifuges, BFPs), but these items can be offered by Andritz as well.

Terms of Payment (Net 30 Days)

- 20% of contract value with purchase order
- Balance of payment will be progress payments based on an agreed schedule of values.
- ** ANDRITZ will be granted an opportunity to run a performance test within ninety (90) days of Buyer notification that the system is ready to test. If, through no fault of ANDRITZ, ANDRITZ is not able to run the performance test in the 90 days, final payment is due in full.

Approval and Certified Drawings

The package which constitutes "Submittal Drawings" is comprised of the following. For invoicing purposes this list is complete. However, additional drawings may be submitted, but not considered part of the "Submittal" package for invoicing purposes:

- P&I Drawings
- General Arrangement Drawings
- Equipment Load Drawings
- Area Utility Requirement Drawings

Shipment

Delivery of Andritz dryer components is estimated to be approx. 10-12 months after return of client approved for construction submittals in order to procure materials and start fabrication.

Erection, Training and Start-up Assistance

ANDRITZ can provide additional erection and start-up supervision for which the purchaser shall pay $1,400.00/day plus expenses, eight (8) hours/day.

At the request of the Purchaser, overtime service will be provided at a rate of 1.5 times quoted rates for weekdays and 2.0 times quoted rates for weekends.

Expenses are defined as the cost of travel from Seller's plant to the point of installation and return, together will all living expenses during the period of service.

The above charges shall be made for time involved including delays which are beyond the Seller's control.

ANDRITZ SEPARATION INC. STANDARD TERMS AND CONDITIONS OF SALE

1. TERMS APPLICABLE

This quotation or acknowledgement and Andritz's sale of Products described in Buyer's purchase order issued in whole or in part in response to this quotation or in response to which this acknowledgement is issued are expressly limited to and expressly made conditional on, Buyer's acceptance of the Terms and Conditions of Sale listed below, which are the exclusive terms and conditions upon which the Andritz entity supplying the same ("Seller") will accept a purchase order for the sale of products, equipment and parts relating thereto ("Products"). These Terms and Conditions of Sale control, supersede and replace any and all other additional and/or different terms and conditions of Buyer, and Seller hereby objects to and rejects all such terms and conditions of Buyer without further notification, except to the extent Seller expressly agrees to such conditions in writing. Seller's commencement of work under the Purchase Order or Buyer's acceptance of delivery of or payment for any Products covered by this Agreement, in whole or in part, shall be deemed Buyer's agreement to the foregoing. The term "this Agreement" as used herein means this quotation or acknowledgment or Buyer's purchase order, together with any attachment thereto, any documents expressly incorporated by reference (but excluding any Buyer terms and conditions attached thereto or incorporated therein by reference), and these Terms and Conditions of Sale.

2. DELIVERY

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

3. WARRANTY

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

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

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

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

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

4. LIMITATION OF LIABILITY

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

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

(b) The aggregate liability of Seller, its officers, directors, employees, subcontractors, suppliers or affiliated companies, for all claims of any kind for any loss, damage, or expense resulting from, arising out of or connected with the Products or this Agreement or from the performance or breach thereof, together with the cost of performing make good obligations to pass performance tests, if applicable, shall in no event exceed the contract price. The foregoing notwithstanding, Seller's aggregate and sole liability for any claims for (a) delay in delivery shall not exceed 5% and (b) failure to achieve performance requirements, shall not exceed 15% of the contract price.

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

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

5. CHANGES, DELETIONS AND EXTRA WORK

Seller will not make changes in the Products unless Buyer and Seller have executed a written Change Order for such change. Any such Change Order will include an appropriate adjustment to the contract price and delivery schedule. If the change impairs Seller's ability to satisfy any of its obligations to Buyer, the Change Order will include appropriate modifications to this Agreement. Seller shall be entitled to a Change Order adjusting the contract price, delivery schedule and/or any affected obligations of Seller if after the date of this Agreement a change in applicable law should require a change in the Products or in the event and to the extent that an act or omission of Buyer, or any error or change in Buyer-provided information, affects the Seller's performance hereunder.

6. TAXES

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

7. SECURITY INTEREST

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

8. SET OFF

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

9. PATENTS

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

10. SOFTWARE LICENSE, WARRANTY, FEES

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

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

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

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

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

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

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

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

11. TERMINATION

(a) Buyer may terminate this Agreement upon breach by Seller of a material obligation hereunder and Seller's failure to cure, or to commence a cure of, such breach within a reasonable period of time (but not less than 30 days) following written receipt of notice of the same from Buyer.

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

12. CONFIDENTIALITY

Buyer acknowledges that the information which Seller submits to Buyer in connection with this Agreement and the performance hereof includes Seller's confidential and proprietary information, both of a technical and commercial nature. Buyer agrees not to disclose such information to third parties without Seller's prior written consent. Seller grants to Buyer a non-exclusive, royalty-free, perpetual license to use Seller's confidential and proprietary information for purposes of the installation, operation, maintenance and repair of the Products that are the subject hereof only. Buyer further agrees not to and not to permit any third party to analyze, measure the properties of or otherwise reverse engineer the Products, fabricate the Products or any parts thereof from Seller's drawings or to use the drawings other than in connection with this Agreement. Buyer will defend and indemnify Seller from any claim, suit or liability based on personal injury (including death) or property damage related to any Product or part thereof which is fabricated by a third party without Seller's prior written consent and from and against related costs, charges and expenses (including attorneys fees). All copies of Seller's confidential and proprietary information shall remain Seller's property and may be reclaimed by Seller at any time in the event Buyer is in breach of its obligations under this Paragraph 13.

13. END USER

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

14. FORCE MAJEURE

(a) Force Majeure Defined. For the purpose of this Agreement "Force Majeure" will mean all events, whether or not foreseeable, beyond the reasonable control of either party which affect the performance of this Agreement, including, without limitation, acts of God, acts or advisories of governmental or quasi-governmental authorities, laws or regulations, strikes, lockouts or other industrial disturbances, acts of public enemy, wars, insurrections, riots, epidemics, pandemics, outbreaks of infectious disease or other threats to public health, lightning, earthquakes, fires, storms, severe weather, floods, sabotage, delays in transportation, rejection of main forgings and castings, lack of available shipping by land, sea or air, lack of dock lighterage or loading or unloading facilities, inability to obtain labor or materials from usual sources, serious accidents involving the work of suppliers or sub-suppliers, thefts and explosions.
(b) Suspension of Obligations. If either Buyer or Seller is unable to carry out its obligations under this Agreement due to Force Majeure, other than the obligation to make payments due hereunder, and the party affected promptly notifies the other of such delay, then all obligations that are affected by Force Majeure will be suspended or reduced for the period of Force Majeure and for such additional time as is required to resume the performance of its obligations, and the delivery schedule will be adjusted to account for the delay.
(c) Option to Terminate. If the period of suspension or reduction of operations will extend for more than four (4) consecutive months or periods of suspension or reduction total more than six (6) months in any twelve (12) month period, then either Buyer or Seller may terminate this Agreement.
(d) Strikes On-Site. Notwithstanding anything herein to the contrary, in the event a strike, lockout, labor, union or other industrial disturbance at Buyer's site affects, delays, disrupts or prevents Seller's performance of this Agreement, Seller shall be entitled to a Change Order containing an appropriate adjustment in the contract price and delivery schedule

15. INDEMNIFICATION AND INSURANCE

(a) Indemnification. Seller agrees to defend and indemnify Buyer from and against any third-party claim for bodily injury or damage to tangible property ("Loss") arising in connection with the Products provided by Seller hereunder or the work performed by Seller hereunder, but only to the extent such Loss has been caused by the negligence, willful misconduct or other legal fault ("Fault") of Seller. Buyer shall promptly tender the defense of any such third-party claim to Seller. Seller shall be entitled to control the defense and resolution of such claim, provided that Buyer shall be entitled to be represented in the matter by counsel of its choosing at Buyer's sole expense. Where such Loss results from the Fault of both Seller and Buyer or a third party, then Seller's defense and indemnity obligation shall be limited to the proportion of the Loss that Seller's Fault bears to the total Fault.
(b) Insurance. Seller shall maintain commercial general liability insurance with limits of $2,000,000 per occurrence and in the aggregate covering claims for bodily injury (including death) and physical property damage arising out of the Products. Seller shall also provide workers' compensation insurance or the like as required by the laws of the jurisdiction where the Services will be performed, and owned and non-owned auto liability insurance with limits of $1,000,000 combined single limit. Seller will provide a Certificate of Insurance certifying the existence of such coverages upon request.

16. GENERAL

(a) Seller represents that any Products or parts thereof manufactured by Seller will be produced in compliance with all applicable federal, state and local laws applicable to their manufacture and in accordance with Seller's engineering standards. Seller shall not be liable for failure of the Products to comply with any other specifications, standards, laws or regulations.
(b) This Agreement shall inure only to the benefit of Buyer and Seller and their respective successors and assigns. Any assignment of this Agreement or any of the rights or obligations hereunder, by either party without the written consent of the other party shall be void.
(c) This Agreement contains the entire and only agreement between the parties with respect to the subject matter hereof and supersedes all prior oral and written understandings between Buyer and Seller concerning the Products and any prior course of dealings or usage of the trade not expressly incorporated herein.
(d) This Agreement may be modified, supplemented or amended only by a writing signed by an authorized representative of Seller. Seller's waiver of any breach by Buyer of any terms of this Agreement must also be in writing and any waiver by Seller or failure by Seller to enforce any of the terms and conditions of this Agreement at any time, shall not affect, limit or waive Seller's right thereafter to enforce and compel strict compliance with every term and condition thereof.
(e) All terms of this Agreement which by their nature should apply after the cancellation, completion or termination of this Agreement shall survive and remain fully enforceable after any cancellation, completion or termination hereof.
(f)(i) If Seller's office is located in the United States, this Agreement and the performance hereof will be governed by and construed according to the laws of the State of Georgia.
(ii) In the circumstances of (f)(i) above, any controversy or claim arising out of or relating to this Agreement, or the breach thereof, or to the Products provided pursuant hereto, shall be definitively settled by arbitration, to the exclusion of courts of law, administered by the American Arbitration Association ("AAA") in accordance with its Construction Industry Arbitration Rules in force at the time this Agreement is signed and to which the parties declare they will adhere (the "AAA Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Atlanta, Georgia by a panel of three members, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the panel and will be appointed by mutual agreement of the two party-appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party-appointed arbitrators to agree within forty-five (45) days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the AAA in accordance with the AAA Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within thirty (30) days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the AAA in accordance with the AAA Rules.
(g)(i) If Seller's office is located in Canada, this Agreement and the performance hereof will be governed by and construed according to the laws of the Province of New Brunswick.
(ii) In the circumstances of (g)(i) above, any controversy or claim arising out of or relating to this Agreement, or the breach thereof, or to the Products provided pursuant hereto, shall be definitively settled under the auspices of the Canadian Commercial Arbitration Centre ("CCAC"), by means of arbitration and to the exclusion of courts of law, in accordance with its General Commercial Arbitration Rules in force at the time the Agreement is signed and to which the parties declare they will adhere (the "CCAC Rules"), and judgment on the award rendered by the arbitrator(s) may be entered in any court having jurisdiction over the party against whom enforcement is sought or having jurisdiction over any of such party's assets. The arbitration shall be conducted in Saint John, New Brunswick by a panel of three arbitrators, one of whom will be appointed by each of Buyer and Seller and the third of whom will be the chairman of the arbitral tribunal and will be appointed by mutual agreement of the two party-appointed arbitrators. All arbitrators must be persons who are not employees, agents, or former employees or agents of either party. In the event of failure of the two party-appointed arbitrators to agree within forty-five (45) days after submission of the dispute to arbitration upon the appointment of the third arbitrator, the third arbitrator will be appointed by the CCAC in accordance with the CCAC Rules. In the event that either of Buyer or Seller fails to appoint an arbitrator within thirty (30) days after submission of the dispute to arbitration, such arbitrator, as well as the third arbitrator, will be appointed by the CCAC in accordance with the CCAC Rules.
(h) In the event this Agreement pertains to the sale of any goods outside the United States or Canada, the parties agree that the United Nations Convention for the International Sale of Goods shall not apply to this Agreement.
(i) The parties hereto have required that this Agreement be drawn up in English. Les parties aux présentes ont exigé que la présente convention soit rédigée en anglais.

April 2017 Rev

4. DRUM DRYING SYSTEM SCOPE OF SUPPLY

4.1 DEFINITIONS

- OWNER + OWNER refers to the entity contracting the work being completed in accordance with the Contract Documents is understood to be Annacis Island WWTP Biosolids Drying Plant for METRO Vancouver.
- VENDOR= ANDRITZ, the person, partnership, corporation, association, or affiliation with which the OWNER executes an agreement for the furnishing of SYSTEM equipment under this contract is understood to be ANDRITZ.
- CONSTRUCTION CONTRACTOR - The person, partnership, corporation, association, or affiliation with which the OWNER shall execute a separate agreement for the construction of a Solids Processing Building and installation of the drying system supplied by the VENDOR.
- ENGINEER - The word "ENGINEER" used herein shall be understood to mean the private engineering firm contracted by the OWNER to design the Solids Processing Building and to manage the installation of the SYSTEM and carry out the intent of the project. The ENGINEER shall act as an agent of the OWNER to the extent such authority has been granted them by their contract with the OWNER.

4.2 SCOPE

- VENDOR shall furnish, provide installation advice and test all the equipment necessary to provide a complete sludge pelletization and drying system including all ancillary equipment as defined below, capable of producing a pelletized and dried product from a partially dewatered, wastewater sludge.
- The work included under this Specification shall be the design, supply of materials, fabrication, testing, loading for shipment and delivery for assembly in OWNER's plant, of one sludge drying, pelletization system with accessories as required for a complete and operable unit for the capacities as herein specified. Also included are installation advice, commissioning services and performance testing.
- Assembly of the dryer equipment shall be by the CONSTRUCTION CONTRACTOR as described in the specifications.
- The general area available for the drying system is shown on the drawings.
- It is the intent of this Specification to describe the process and mechanical components comprising the sludge pelletization and drying system and to establish minimum quality standards for materials and process performance.
- VENDOR shall minimize fugitive odor and dust emissions by proper design and ventilation of the equipment as required by this specification.
- It is the intent of this Specification to obtain a system complete, including but not limited to anchor bolts, fasteners, and interconnecting equipment, including all interconnecting ductwork and chutes. The VENDOR shall furnish a complete Instrumentation and Control system for the sludge drying and pelletization system. The system shall include all measuring elements, control devices, signal converters, transmitters, local control panels, motor control centers, digital hardware and software, operation workstations, and communication networks to provide the functions indicated, however all conduit, cable and labor required for installation is by others.
- Each dryer system shall include a regenerative thermal oxidizer (RTO) with exhaust stack.
- All equipment shall be designed to operate with 100% natural gas.

Items to be included in the Dryer system shall include,

1. Conveying, mixing and storage equipment to mix dewatered sludge cake and previously dried and crushed sludge (recycle) to form a uniformly coated (dry solids interior/wet solids exterior) pellet for introduction into the dryer. Includes wet material bin with cake pumps, recycle bin, metering screw conveyors, and mixer.

2. A direct-fired furnace capable of being fired with natural gas. Flame safety panels shall be included with the furnace.
3. Direct-heat, concurrent triple pass rotary drum dryer to produce dried sludge pellets within the dryer drum such that no ancillary pelletization equipment is required.
4. Solids separation equipment for removing the dried sludge from the process gas stream, including preseparator and polycyclone systems.
5. Solids handling, conveying, and classifying equipment for separating solids into product, undersize (fines), oversize and trash fractions.
6. Solids processing equipment for generating, storing and conveying recycled solids, including crusher, recycle storage and conveying equipment.
7. Product cooler.
8. Pneumatic conveying equipment for transporting product to storage silo.
9. Total of (2) product storage silos with 200 tonnes storage of dried product storage capacity.
10. Condenser for removal of moisture from the gas stream and a venturi scrubber for control of particulates and gaseous emissions.
11. Fans required for the conveyance of air through the process units, including the main process induced draft fan, the venturi induced draft fan and the combustion air fan.
12. One (1) dust collection system including dust baghouse with deflagration vent and rotary valve, dust collection system exhaust fan and ductwork servicing only those process components supplied by the VENDOR and located in the sludge drying and pelletization facility building.
13. Deflagration venting system and deflagration prevention systems. Electrical system components to include motors, motor control centers, electrical power panels and variable frequency drives.
14. Access provisions including platforms, catwalks, ladders, handrails and stairways as shown in the proposal drawings.
15. Complete Instrumentation and Controls package including control panels, PLC, MCC, and field instruments required for a complete system.

4.3 WORK BY OTHERS AND SYSTEM INTERFACES

- The sludge drying and pelletization system, specified herein, shall be installed by the CONSTRUCTION CONTRACTOR. The VENDOR shall assist during specific times of the installation of the sludge drying and pelletization equipment.
- The equipment shall be unloaded at the plant site by the CONSTRUCTION CONTRACTOR.
- The dewatered sludge cake will be delivered to a wet sludge receiving bin via inlet chutes. The VENDOR shall provide process equipment downstream of the wet sludge receiving bin chute inlet.
- No component of the sludge drying and pelletization system shall be supported from the building roof or walls unless approved by the Owner’s Engineer. Primary equipment loads from the sludge drying and pelletization system shall be transferred to the floor slab only.
- The CONSTRUCTION CONTRACTOR shall provide conduits, raceways, wire and other appurtenances not provided by the VENDOR. The CONSTRUCTION CONTRACTOR shall provide grounding and bonding of all equipment and electronic controls. Design of grounding plan and routing plan of conduit and cable shall be by others.
- The VENDOR shall size piping systems that are an integral part of the sludge drying and pelletization system. Interface for utility connections shall be located at the flanges of supplied equipment. The CONSTRUCTION CONTRACTOR shall all provide interconnecting piping and supports. Piping systems sized by VENDOR are limited to those required for the sludge drying and pelletization system.

- The VENDOR shall coordinate the location of utility connections and penetrations with the CONSTRUCTION CONTRACTOR.
- Monorails for lifting/hoisting will be provided on the underside of the preseparator/polycyclone within the confines of the preseparator tower only.

The VENDOR's scope does not include the following:

- Building
- Concrete work
- Drains and drain piping
- Supply and/or installation of any utility piping and interconnecting piping and supports, including but not limited to:
  - Potable water;
  - Non-potable water;
  - Compressed air, including control/instrument air;
  - Natural gas supply
  - Nitrogen gas
- All field wiring, including conduit, electrical service to the motor control center, connection to all instruments and motors, installation of instruments and motors, local disconnects and emergency stops, connection of instruments to PLC cabinet, wiring between panels, etc.;
- Lateral supports for the bucket elevators and supports for process and fugitive dust system ductwork.
- Overhead building crane
- State, Local and Federal taxes.
- Ground bonding jumpers.
- Building service utilities including lighting, HVAC, utility stations, convenience power, etc.
- Sludge cake pipe to load out.

Clarifications to the Scope of Supply;

- All foundations/housekeeping pads by CONSTRUCTION CONTRACTOR.
- Some components require some assembly on-site. VENDOR will work closely with the CONSTRUCTION CONTRACTOR during assembly of these components.
- VENDOR will provide an erection advisor for thirty (30) days. Any calendar days exceeding thirty (30) will be at the expense of the CONSTRUCTION CONTRACTOR per the ANDRITZ standard rate sheet.
- VENDOR will provide services to field test, start-up, air emissions testing and reporting, follow on services and train plant personnel in the operation of the plant.
- CONSTRUCTION CONTRACTOR shall provide mechanical and electrical support personnel for the “shakeout” period expected to run for up to 5-6 weeks.

5. DRUM DRYER SYSTEM DESCRIPTION OF OPERATION

ANDRITZ Separation Inc. offers the Drum Drying System (DDS), for use in the proposed Class A sludge dryer facility. The DDS technology is a direct drying process that mixes heated air with biosolids in a triple-pass rotary drum dryer designed and manufactured by ANDRITZ Separation Inc. The heated air comes in contact with the biosolids in the rotating drum, evaporates water and produces a dry hard pellet. With operating installations dating back to 1974, the DDS technology has proven itself to be the industry leader in terms of uptime, cost of ownership, efficient material handling, extremely low air emissions, and effective odor control. The proposed drying system is a proven process with millions of tons of biosolids converted to beneficial use and over 25 years of successful operating experience.

The dryer system proposed for this project includes, among other
ANDRITZ innovations, high-rate exhaust gas recirculation, which increases the efficiency of the drying system and reduces total dryer system air emissions and odor potential.
Presently, more than 130 ANDRITZ DDS systems are either operational or under construction worldwide, including one of America's largest heat drying and pelletization dryer system pictured in Philadelphia, PA, (2 x DDS 110X units operating since early 2012).

ANDRITZ Drum Drying System

Highlights of the proposed Drum Drying System are summarized below:

- Technology for odor & noise will be used to minimize air emission, odors and noise. (e.g. regenerative thermal oxidizers, multistage scrubbing system, etc.).
- The dryer system will produce a Class A product per U.S. EPA 40 CFR Part 503 Regulations.
- The dryer system will use natural gas as its primary fuel.
- The dryer system will feature a unique triple-pass drying drum for even drying of the biosolids pellets and the best thermal efficiency in the industry.
- Mixing technology will be used to blend incoming dewatered biosolids with recycled dry material to achieve granulation/pelletization and produce a high quality finished product for beneficial use.
- Advanced screening, cooling, and dense phase pneumatic conveying systems will be used to maintain pellet quality/integrity during transport to on-site storage silos and delivery to market.A high rate exhaust gas recirculation technology will be used for efficiency of air emission, odor and dust control.

- The dryer system design incorporates air emission and odor control systems consisting of polycyclones, impingement trays, condensers/sub-coolers, venturi scrubbers, and regenerative thermal oxidizers (RTO) for the process off-gas emission control.
- The dryer system will be monitored and controlled by sophisticated PLC and PC-based computer interfaces that conform to the highest industry standards for process control and operation safety.
- Only proven, simple and effective materials handling techniques will be used to ensure reliable operation and high availability.
- High efficiency heat exchange generated by the impingement tray's condensers/sub-coolers yields hot water at >140°F, which can be used to provide energy for digester heating or space heating purposes.

ANDRITZ Drum Drying System with high rate gas recirculation

The following sections describe the steps of the DDS heat drying and pelletizing process and the sub-systems that will be included in the dryer system:

Step 1: High Solids Centrifuge or Belt Press Dewatering (not included in this ANDRITZ offer)
Step 2: Materials transport
Step 3: Heat generation
Step 4: Preparation of biosolids for drying
Step 5: Evaporation of moisture
Step 6: Air/solids separation devices
Step 7: Dry material preparation
Step 8: Treatment of process exhaust gas
Step 9: Storage of commercial pellets and loading of trucks
Step 10: Electrical supply, instrumentation and controls

The result of the proper coordination of these processes is a low environmental impact dryer system producing high quality pellets of 90% minimum dry solids, with a uniform size distribution from 0.5 - 4 mm. Air emissions, odor, and noise are controlled. The dryer system will rank amongst the best in the world in terms of utility of function, industrial design, and environmental friendliness.

The DDS Process – Step One: Receipt of Dewatered Cake

Manatee County, FL Drum Drying System

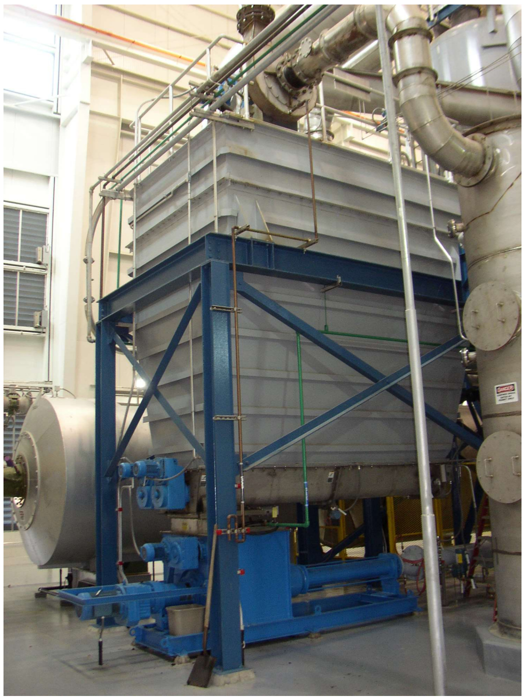
At Manatee County, FL, the Drum Drying Facility, dewatered cake is received via dump trucks from other County wastewater treatment plants – the truck receiving area is seen in the above photo on the left - two (2) live bottom hoppers approx. 30 m3 capacity with live bottoms and PC pumps delivering cake to the Drum Dryer's wet material bim located in the building.

There are no cake storage hoppers provided at this facility.

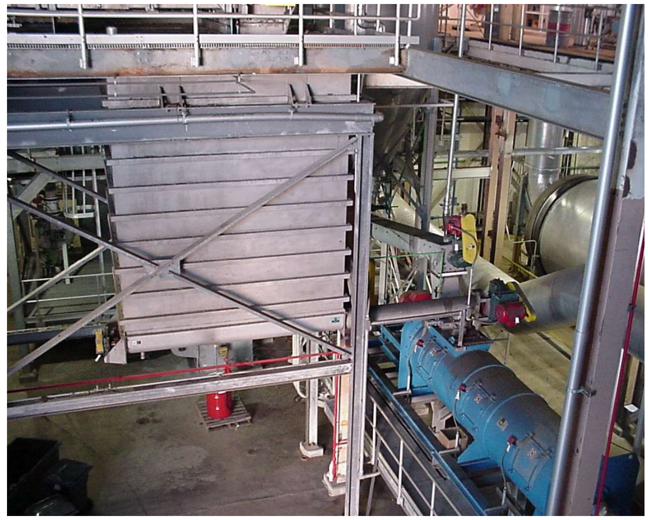
Final Product silos are shown in the foreground.

The DDS Process – Step Two: Material Transport

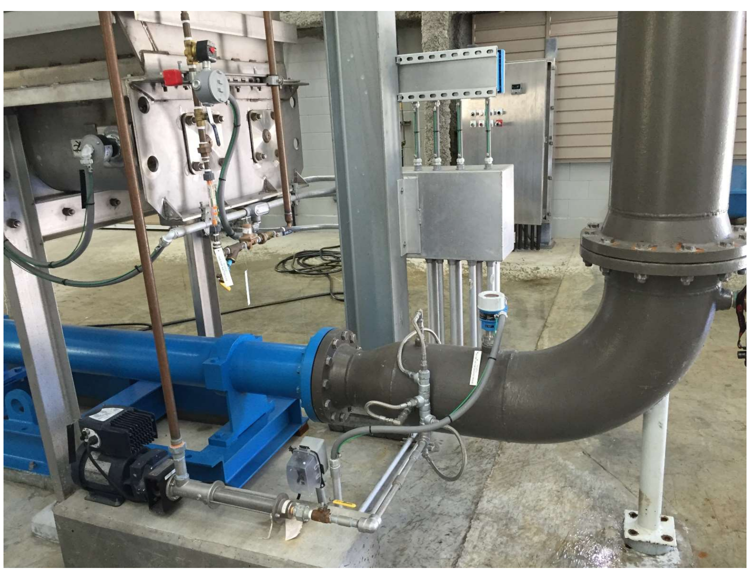
The dewatered biosolids will be conveyed or pumped (by other) to the proposed dryer system’s storage hopper. The cake bin(s) will also be vented to an odor control system (by other) for the facility.



Cake bin discharging to progressing cavity pump



Proven cake bin design



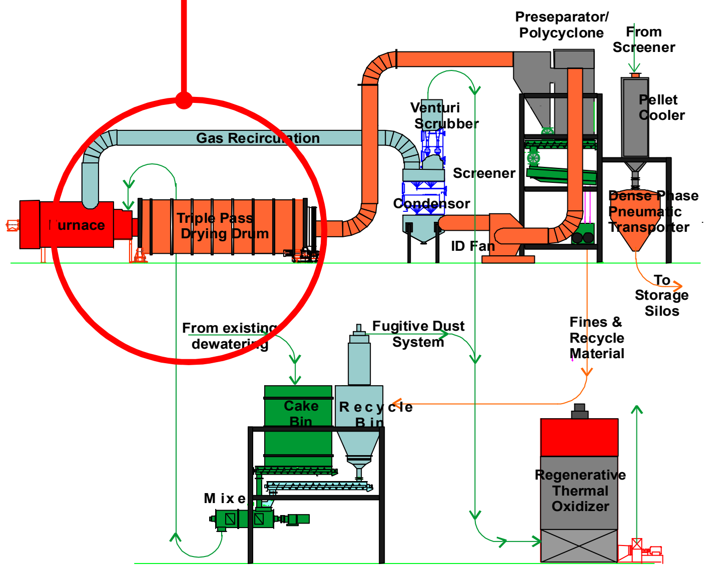
Cary, NC - wet cake pump with lubrication assembly

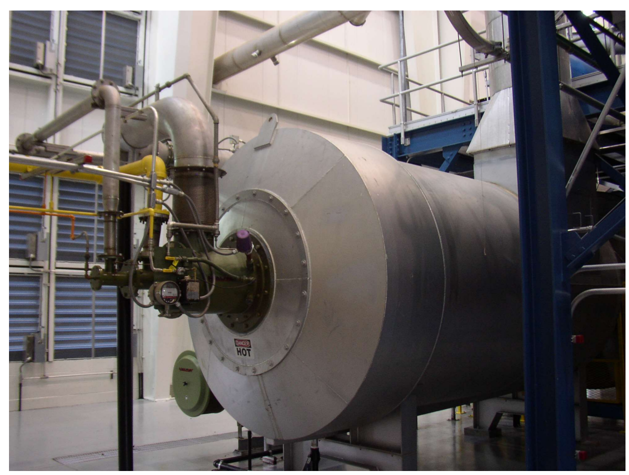
The DDS Process – Step Three: Heat Generation

The key criteria is the ability to maintain and regulate a consistent set point temperature at the discharge end of the drying drum.

The proposed dryer system will be designed to use natural gas as a primary heat source.

Recirculated exhaust gas will be taken into the furnace near the end opposite the burner, and carried toward the flame via an insulated outer jacket. This jacket helps to pre-heat the air, and to protect the flame from the disturbance of incoming air. An additional protective cylinder around the flame further enhances the complete ignition of the supplied fuel. The now-heated air will be pulled through the furnace by an induced draft fan, which will follow the air/solid (preseparator/ polycyclone) separation devices. The temperature of the air at the exit of the furnace will be maintained at 850°F to 950°F. The burner firing rate will be controlled by a PLC PID loop with the dryer exhaust temperature as the controlling variable. Heat energy consumed in the furnace can be recovered in the form of hot water and reused for digester or building heating.

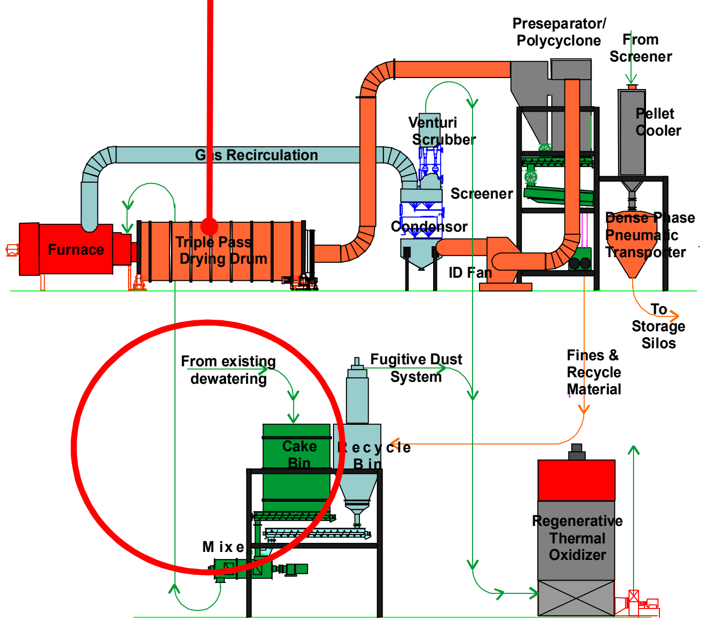




Direct-fired furnace with high rate gas recirculation

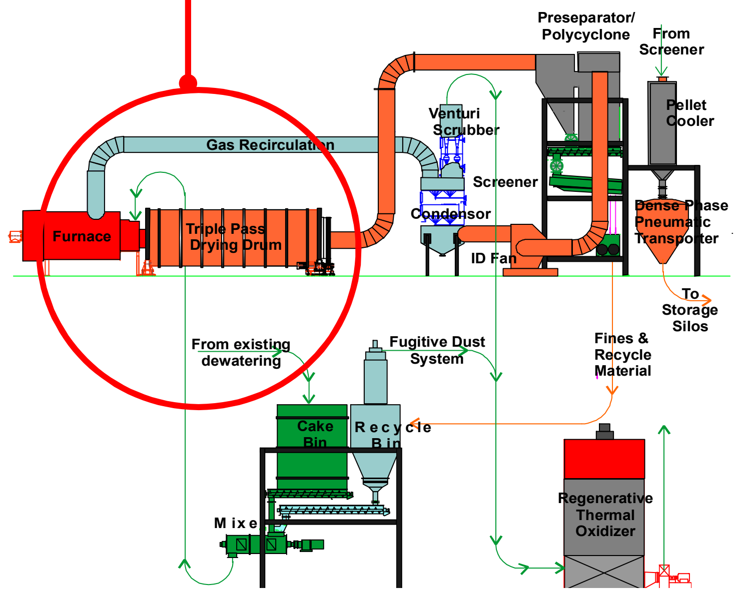
The DDS Process – Step Four: Preparation of Biosolids for Drying

The proposed dryer system will use a portion of the already-dried material (recycle) to prepare the dewatered biosolids for the drying process. Mixing the biosolids, or “wet” material, coats the dried particles or “recycled” material, to obtain a mixture in the 60% - 70% dry solids content range. The low-speed high intensity mixer features a constant speed and a proven single-shaft, plow-share design for high quality pellet formation. The benefit of this procedure is that the final product will never be wet on the inside since the core of the particle is dry before reaching the dryer. As a result, a high quality, uniform final product will be produce
The mixture is fed into the drying drum.



(Foreground) Single shaft plowshare mixer

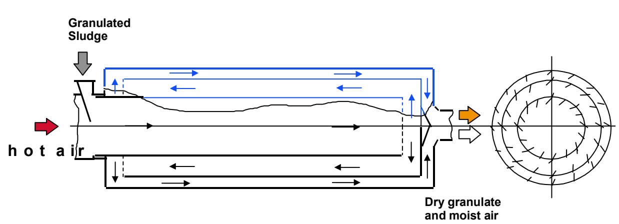
The DDS Process – Step Five: Evaporation of Moisture



Evaporation of water from the pre-formed pellets takes place in the triple-pass, rotating drum. High speed air and the drum's rotation will pull the pellets through the drum until such time as they are dry enough and, therefore, light enough to be lifted and carried by the air stream out of the drum. The repetitive dry-lift-dry-lift cycle, combined with the dryness/ density based retention time, ensures that the pellets are never over-dried, thus avoiding the creation of an unnecessarily high odor load in the process air stream. This method of avoiding odor generation is an advancement which, though relatively simple, is an example of the process related odor control experience that was identified earlier as one of the material key points of knowledge and experience that separates ANDRITZ DDS Drum Dryer from other biosolids drying processes.

The drying drum consists of three concentric cylinders arranged so that pellets will flow through the innermost cylinder, back through the middle cylinder and, finally, through the outer cylinder. Flights on the inner walls of the cylinders lift the material and cascade it into the hot airstream. The triple-pass design of the drum will make the most efficient use of the heat and building space. It will also create a better granulate than any single-pass drum because the fall during the rotation of the drum is much shorter. The rotation of the drum, combined with the shorter fall distance during rotation, are design features incorporated to ensure that a high quality product is produced.

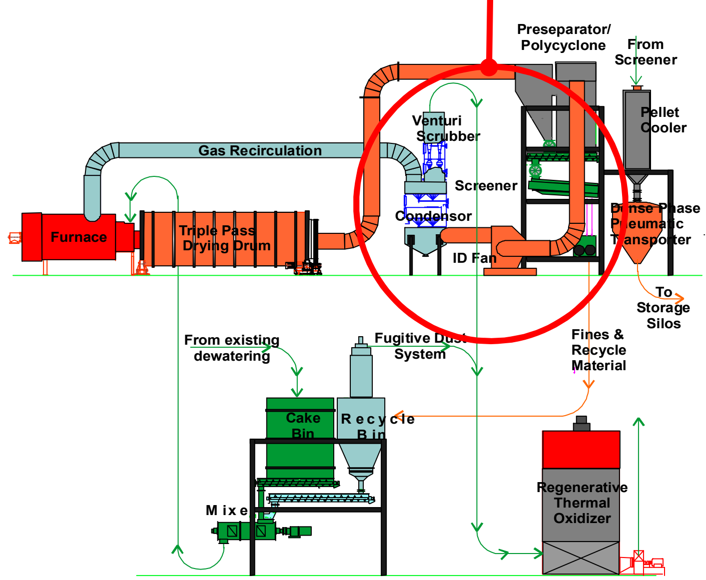
A thermocouple at the discharge end of the drying drum will regulate the burner to maintain a consistent exit air temperature. Two additional thermocouples at the discharge of the drum will monitor for excessively high or low temperatures, which could indicate thermocouple malfunctions. Another thermocouple at the inlet end of the drum serves as a further safety measure against high temperatures.



Schematic of Triple Pass Drum Dryer

ANDRITZ Triple Pass Drum Dryer (DDS) with Recycle Bin shown in background

The DDS Process – Step Six:- Air/Solids Separation



At the exit of the drying drum, the high-speed exhaust gas will be carrying evaporated moisture and dried granules. The DDS system uses a two-stage separation process to remove most of the finished product and particulate load from the air stream.

The first stage of the air/solids separation process is a pre-separator; a large chamber with a steel plate mounted perpendicular to the gas flow. As the exhaust gas enters this chamber it will be forced to change direction, causing a separation of pelletized product from the exhaust gas.

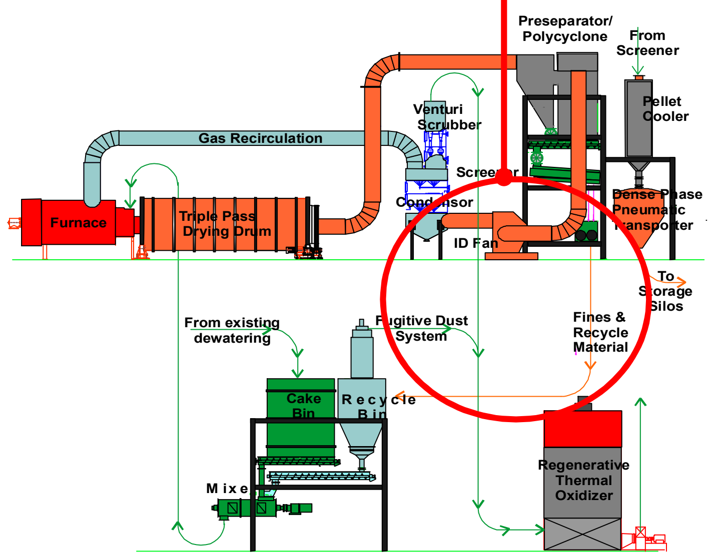
Second, a proprietary polycyclone will be employed to limit the amount of suspended solids passing to the condenser. A rotary valve is located below the pre-separator and polycyclone to allow for discharge of the captured solids while maintaining the pressure differential in the system.

This system has proven to be simple and low maintenance, with low pressure drop for energy efficiency.

Preseparator/Polycyclone –discharging to screener

The DDS Process – Step Seven: Dry Material Preparation

The material exiting the rotary valve following the air/solids separation equipment will consist of dry pellets of many sizes. Most beneficial use options require a uniform distribution of particle size. A narrow particle size distribution along with very low amounts of dust will make the final product considerably more attractive to a wide variety of end-users. For this reason, the product will be classified by size prior to discharge as final product.



Preseparator/Polycyclone

The ANDRITZ DDS dryer system will employ a totally enclosed, multi-layered vibrating screen to separate the pellets into three fractions according to size. The vibrating screen will be designed to minimize floor vibration and dust escape during operation.

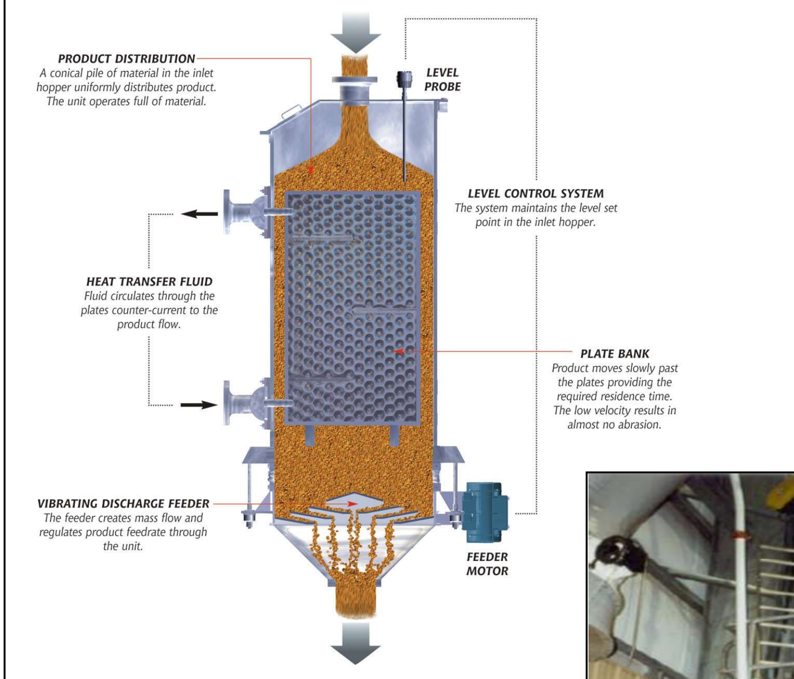
Oversize pellets will be sent through a roller mill and crushed. The crushed particles will then be mixed with under-sized particles and returned to the recycle bin via a screw conveyor and bucket elevator. If the volume of over-sized and under-sized pellets is insufficient to satisfy the requirement for recycle material in the pelletizing process, a modulating valve will send a stream of product sized pellets through the roller mill and from there to the recycle bin based on the bin’s level.

ANDRITZ “Rotoshaker” vibrating screen

The high quality pellets will be cooled in a parallel plate, non-contact heat exchanger to reduce pellet temperature to <100°F using plant effluent water. After cooling, dense phase pneumatic conveying will be used to gently move the now marketable commercial grade pellets to the finished product storage silos.

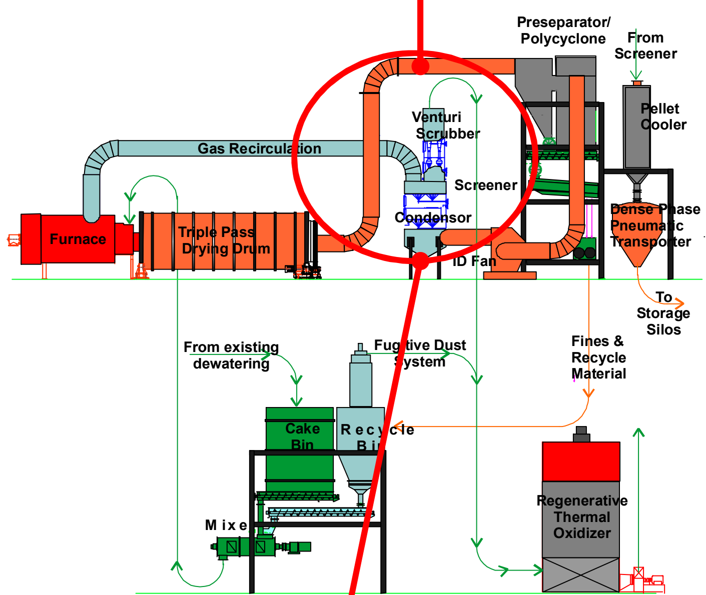
Advantages of the proposed product handling systems:

- Use of plant effluent (reclaimed water) as a non-contact cooling medium
- No air associated with cooling
- Proven design
- Dense phase gentle pneumatic conveying of marketable pellets



Pellet Cooler

The DDS Process – Step Eight: Treatment of Process Exhaust Gas



The hot exhaust gas exiting the separation devices will be carrying a large amount of water vapor. While most of the solid particles will have been removed, there will still be some fine particulate matter and condensable volatile materials (VOMs) suspended in the gas stream. The proposed dryer system will use an impingement tray condenser/sub-cooler tower to cool the gas, causing the evaporated moisture to condense and drop out, while at the same time removing most of the remaining particles and condensable volatile compounds from the exhaust gas stream. Hot gas will enter the tower from the bottom and flow counter-current to water flooding onto three trays. The effect will be two-fold: First, the temperature of the gas will drop from 200ºF to approximately 120ºF, condensing the evaporated moisture, condensable volatile materials (VOMs), and ammonia; Second, the water will wash these materials out of the dryer system and back to the host plant for treatment. One of the features that makes the DDS superior to other drying processes is the high rate recirculation of exhaust gas. Following the impingement tray condenser/sub-cooler, the gas is split into two streams; a large portion of the air is returned to the furnace, leaving only a small side stream to be sent to the final emission and odor treatment equipment. This is another practical example of the advantages of the ANDRITZ DDS system. The greatly reduced air flow is diverted to the emissions and odor control equipment, allowing significantly easier and more complete emissions treatment. The gas stream passes through a venturi scrubber for removal of micron sized particulates and then it is directed to regenerative thermal oxidizers (RTOs) for thermal destruction (oxidation) of odor compounds, CO and VOMs. The odor and air emissions control and reduction processes, including multiple scrubbers and RTO, are further described in the section entitled Air Emissions**.**

DD

The RTO is a multi-chamber type with packing. These units operate with high a thermal efficiency and high destruction and removal efficiencies. Recirculation of the exhaust gas and other design features in the proposed system will result in excellent thermal efficiency. Unlike other systems which utilize air recirculation, the ANDRITZ process includes a dedicated RTO to insure odor/air pollution control during start-up, regular operations and shut-down. This is superior to relying on the dryer furnace for odor/air pollution control, since the furnace is only firing when the dryer drum is running (not effective during start-up and shut-down).

Pierce County, Tacoma WA showing RTO

The additional effect of this gas recirculation feature is maintenance of an oxygen content of 5% - 10% (by volume) in the drying drum, a level considered inert by U.S. regulatory agencies. This significantly enhances the safety of the system as fire/explosion cannot be supported in this atmosphere. The cleaned process gas will be released to the atmosphere through a separate vent above the dryer system building.

Three Canister Regenerative Thermal Oxidizer (RTO)

The DDS Process – Step Nine: Storage of Commercial Pellets for Loading of Final Product.

The commercial pellets will be pneumatically conveyed to the final product storage silos by means of a dense-phase pneumatic conveyance system. Two (2) final product storage silos will be provided.

The final product storage silos and associated material handling system will have the following features:

The storage silos will be out loaded using a telescopic unloading spout. Aspiration air will be vented to a baghouse for dust collection and activated carbon canister to control odors.

Product level in the silos will be monitored and controlled via ultra-sonic continuous level detection.

The silo contents will be continuously monitored for temperature using thermocouple ropes.

In the event of a temperature rise in the silos, nitrogen will be introduced to displace oxygen in the silos and stabilize temperatures.

Two (2) ea. Product Storage Silos

Two (2) DDS-120, Philadelphia, PA with three (3) 500 ton (nominal) final product silos

The DDS Process – Step Ten: Electrical, Instrumentation, and Controls

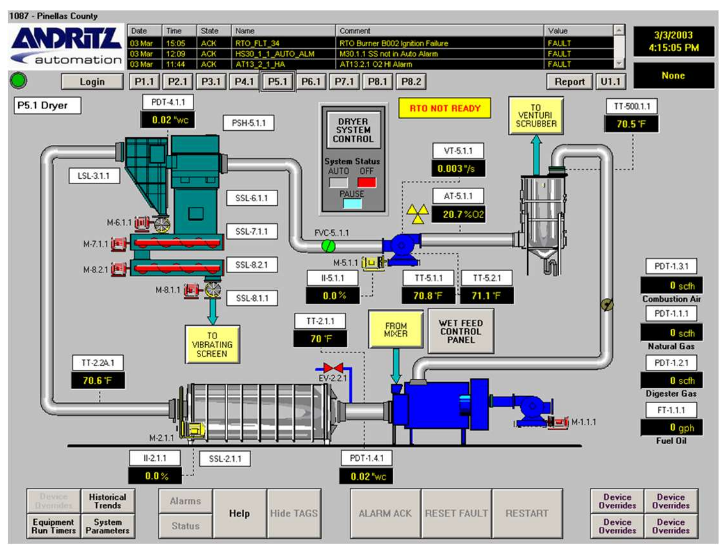
Comprehensive process control and automation will be provided using PLC controls. The process variables will be monitored and accessed with a graphical operator interface created with Wonderware's InTouch© software. The pre-programmed InTouch© software will be loaded onto a desktop computer with menu driven command system that is extremely easy to use.

The system will allow monitoring and control commands to be carried out from the operator keyboard or mouse, with function keys or icons used to select different screens or process monitoring and control alternatives. The drying system application will have multiple process display screens.

Historical data and trends will be displayed to allow short- and long-term analysis of plant performance and stability. Other processes located in the dryer system, including odor control, wet cake and pellet handling, pump stations, etc. will be incorporated into the control system. Alarm and status reports will also be displayed and printed.

An operator interface terminal will be located at the ground floor level for convenience of control and monitoring plant processes.

Control Room



ANDRITZ DDS Operator Interface Screen

Final Product

The ANDRITZ DDS technology is currently in use at more than 130 installations around the world and is a proven technology for recycling biosolids into marketable, high quality pelletized fertilizer or fuel.
The pellets can be used for a wide range of fuel or fertilizer applications from the most basic, such as agricultural fertilizer filler, to the more sophisticated such as the feeding of sensitive turf and ornamental plants.
The proposed facility will convert the biosolids into a marketable fuel or fertilizer. The following major product quality requirements will be met:

DDS Granules

- Moisture content greater than 90% total solids
- Nutrient content (N-P-K, micronutrient, organic content): except for volatilizing ammonia, the drying and pelletizing process will not alter the nitrogen-phosphorous - potassium (N-P-K), micronutrient (including trace metals), and organic matter content of the digested and dewatered solids.
- Pellet size range from 0.5 - 4 mm in size with minimum dust or foreign matter.
- Typical Pellet bulk density is expected to range from 30 to 55 pounds/cubic foot.
- Durability - Pellets will withstand the normal rigors of transportation, handling and mixing without producing excessive levels of dust.
- Pathogen and vector attraction reduction - The US EPA 40 CFR Part 503 Regulations define processing conditions which enable a biosolids product to meet Class A (PFRP) standards. The proposed drying process meets Class A pathogen and vector attraction reduction requirements as specified in §503.32(7)(ii) Appendix B and §503.33(a)(8).

DDS Granules - Louisville, KY

"Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80°C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80°C."

Vector attraction reduction requirements under Part 503 regulations are achieved by drying the biosolids to at least 90% [§503.33(a)(8)]. By meeting these 503 standards, marketing and beneficially use of the pelletized biosolids as a fertilizer throughout the U.S. market is achievable.

6. DRUM DRYING SYSTEM PRELIMINARY DRAWINGS

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- General Arrangement Drawings are enclosed for the Philadelphia Project (two (2) x DDS-120). Note that in this Budget proposal, we are offering to provide two (2) DDS-100 Drum Drying Systems

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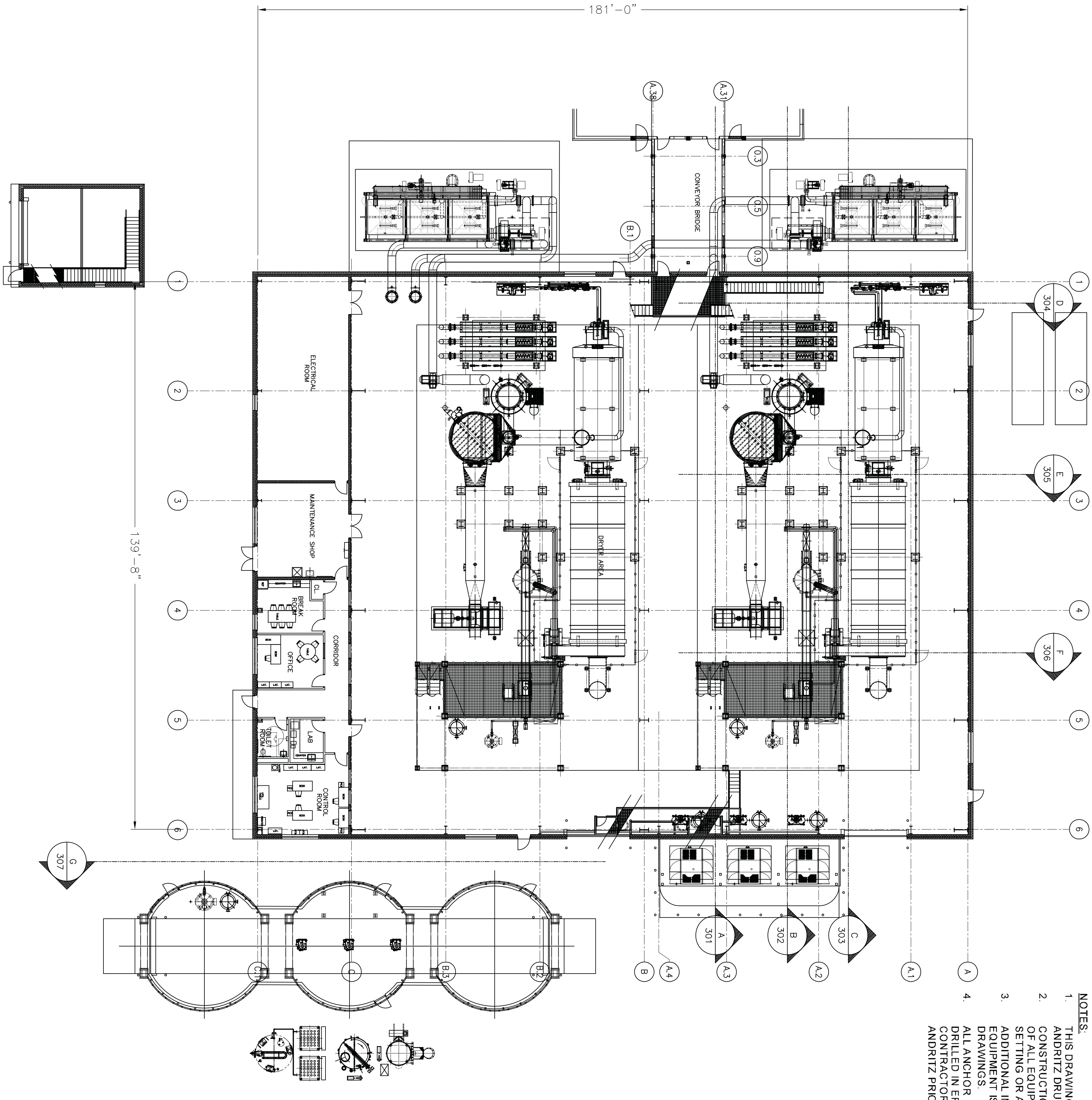

NOTES:

1. THIS DRAWING IDENTIFIES THE STANDARD LAYOUT FOR THE ANDRITZ DRUM DRYING SYSTEM.
2. CONSTRUCTION CONTRACTOR SHALL CONFIRM THE LOCATIONS OF ALL EQUIPMENT WITH ANDRITZ AND/OR KEA PRIOR TO SETTING OR ANCHORING ALL EQUIPMENT.
3. ADDITIONAL INSTALLATION REQUIREMENTS FOR THE ANDRITZ EQUIPMENT IS PROVIDED ON THE ANDRITZ EQUIPMENT SERIES DRAWINGS.
4. ALL ANCHOR BOLTS FOR THE ANDRITZ EQUIPMENT SHALL BE DRILLED IN EPOXY ANCHORS (U.N.O.) FURNISHED BY ANDRITZ. CONTRACTOR SHALL CONFIRM ANCHOR BOLT LOCATIONS WITH ANDRITZ PRIOR TO THEIR INSTALLATION.

JOB NAME	DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792	DRAWN BY: DAN	DATE: 4/14/09
		CHECKED BY:	DATE:
		APPROVED BY:	DATE:
TITLE	DRYER AREA LEVEL 1 PLAN VIEW	SCALE: 1/16"=1'-0"	FILE ME101
		SIZE 110X	

REV	REVISION	DATE
2	DEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

PROJECT NUMBER 1194879-1
DRAWING NUMBER ME-101 REV 2
SHEET 1 OF 1

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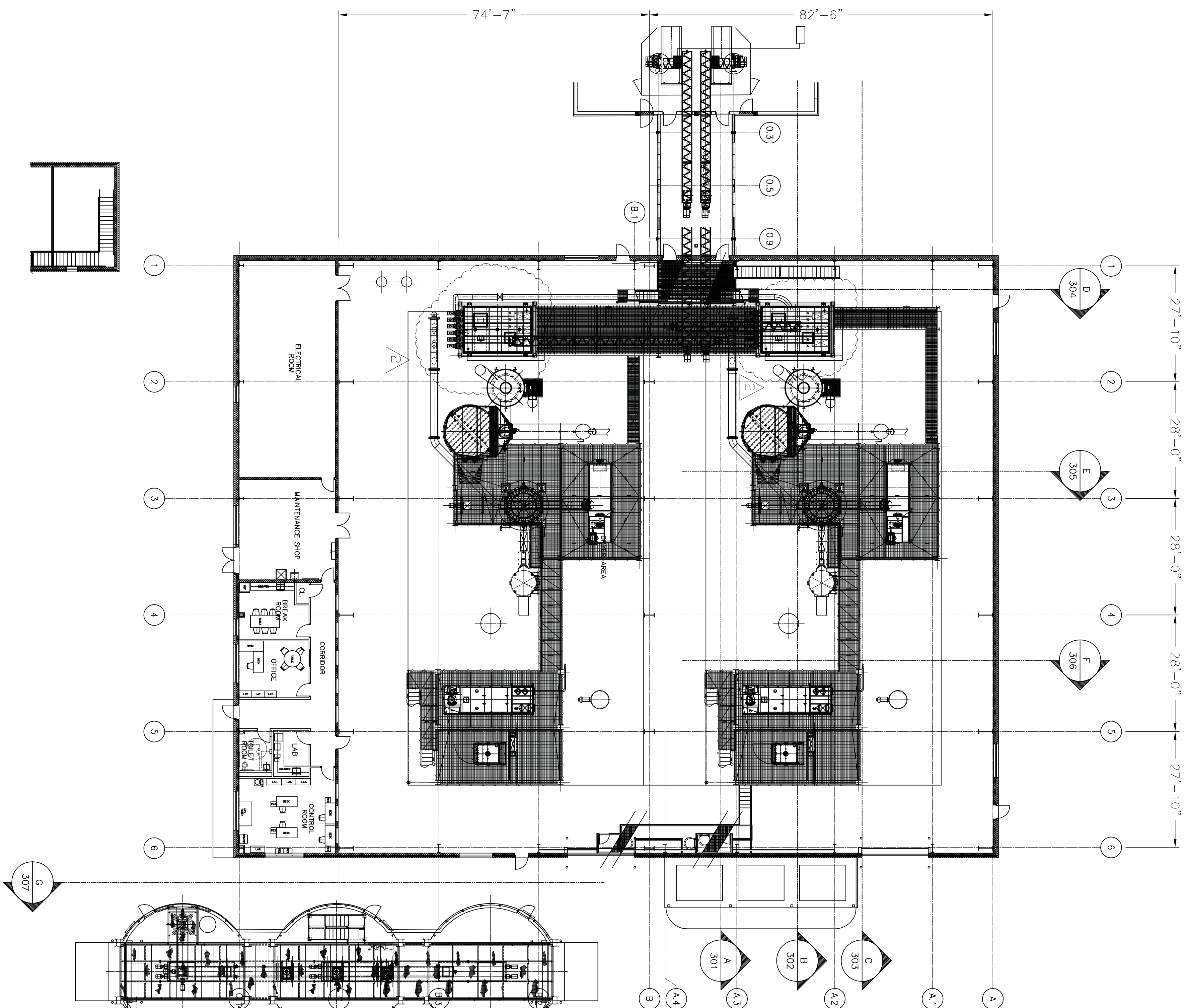

REVIEWED FOR CONSTRUCTION

REV	REVISION	DATE
3	OEM AS BUILT	03/23/12
2	ROTATED LIVE BOTTOMS TO ISLE SIDE	9/3/10
1	GENERAL REVISIONS	8/23/10

JOB NAME: DETROIT WATER AND SEWAGE DEPARTMENT
DETROIT PC-792

TITLE: DRYER AREA
LEVEL 2 PLAN VIEW

PROJECT NUMBER: 1194879-1
DRAWING NUMBER: ME-102 REV 3
SHEET 1 OF 1

DRAWN BY: DAN DATE: 9/15/09
CHECKED BY: DATE:
APPROVED BY: DATE:
SCALE: 1/16"=1'-0" FILE ME102
SIZE 110X

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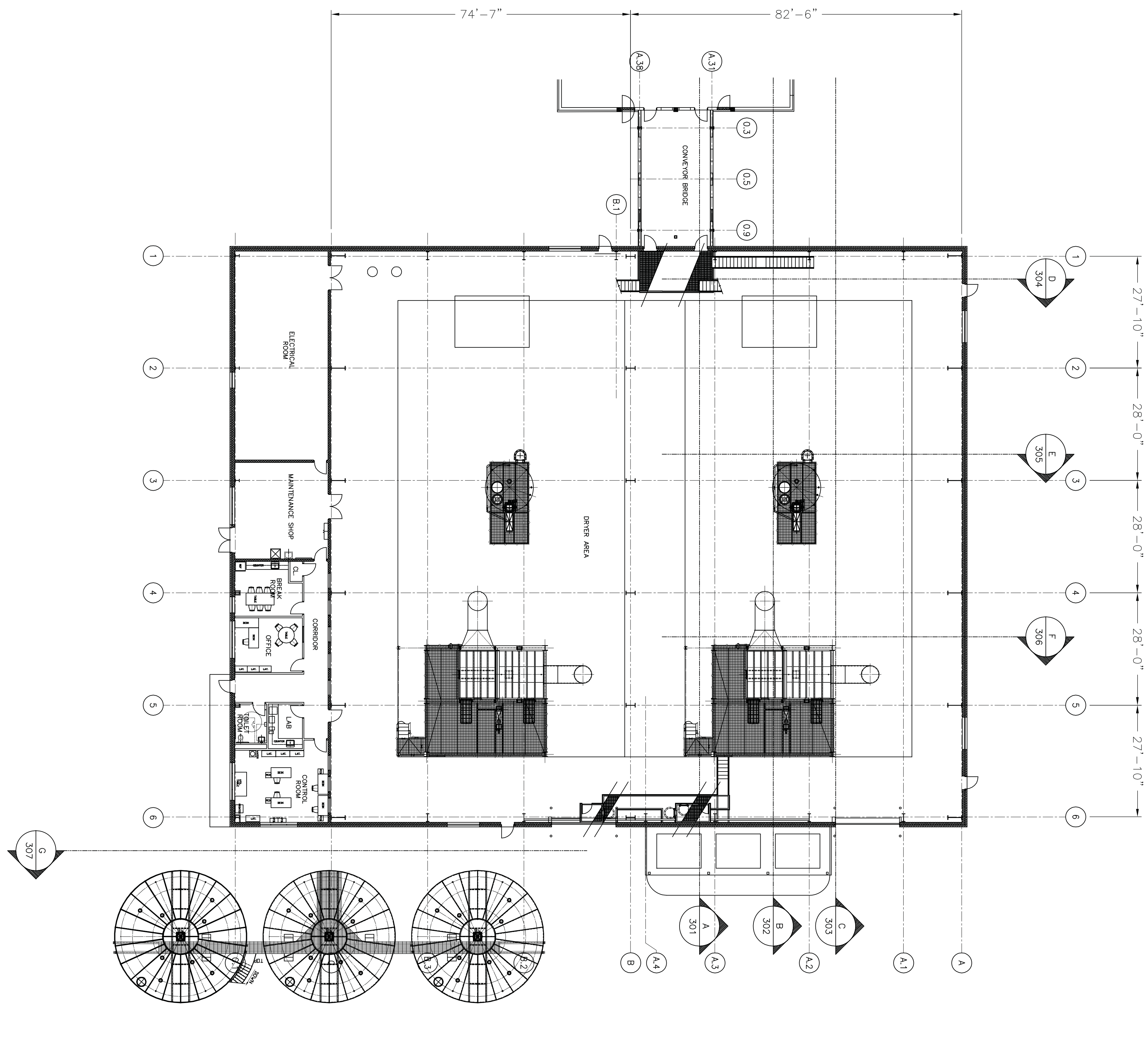

JOB NAME	DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792
TITLE	DRYER AREA LEVEL 3 PLAN VIEW
PROJECT NUMBER	1194879-1
DRAWING NUMBER	ME-103
REV	2
SHEET	1 OF 1
DRAWN BY:	DAN
DATE:	9/15/09
CHECKED BY:	
APPROVED BY:	
SCALE:	1/16"=1'-0"
FILE	ME103
SIZE	110X

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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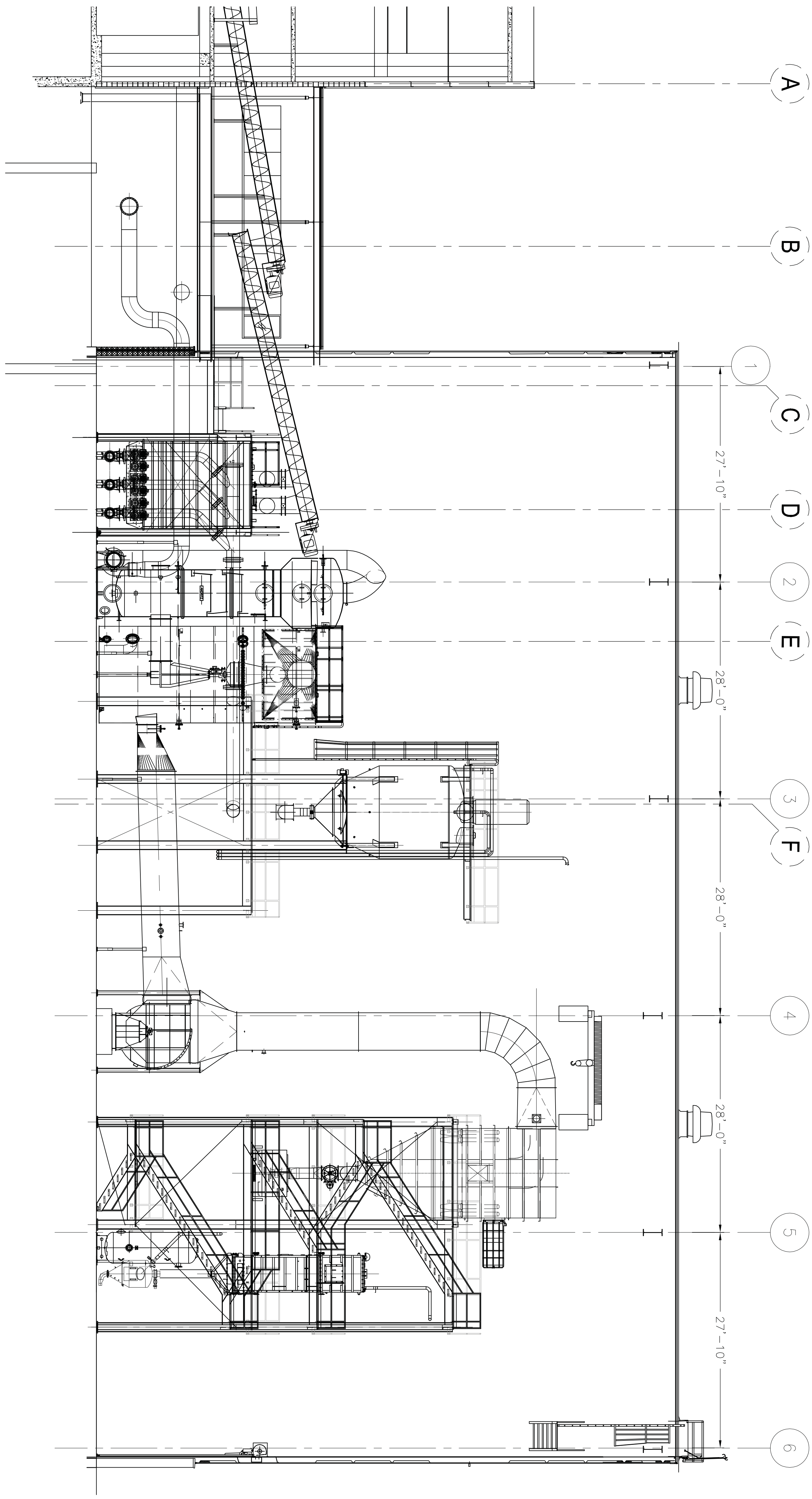

SECTION A
1/8"=1'-0"

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		CHECKED BY:	DATE:
		APPROVED BY:	DATE:
TITLE	DRYER AREA SECTION A-A	SCALE: 1/8"=1'-0"	FILE ME301
		SIZE 110X	

PROJECT NUMBER 1194879-1
DRAWING NUMBER ME-301 REV 2
SHEET 1 OF 1

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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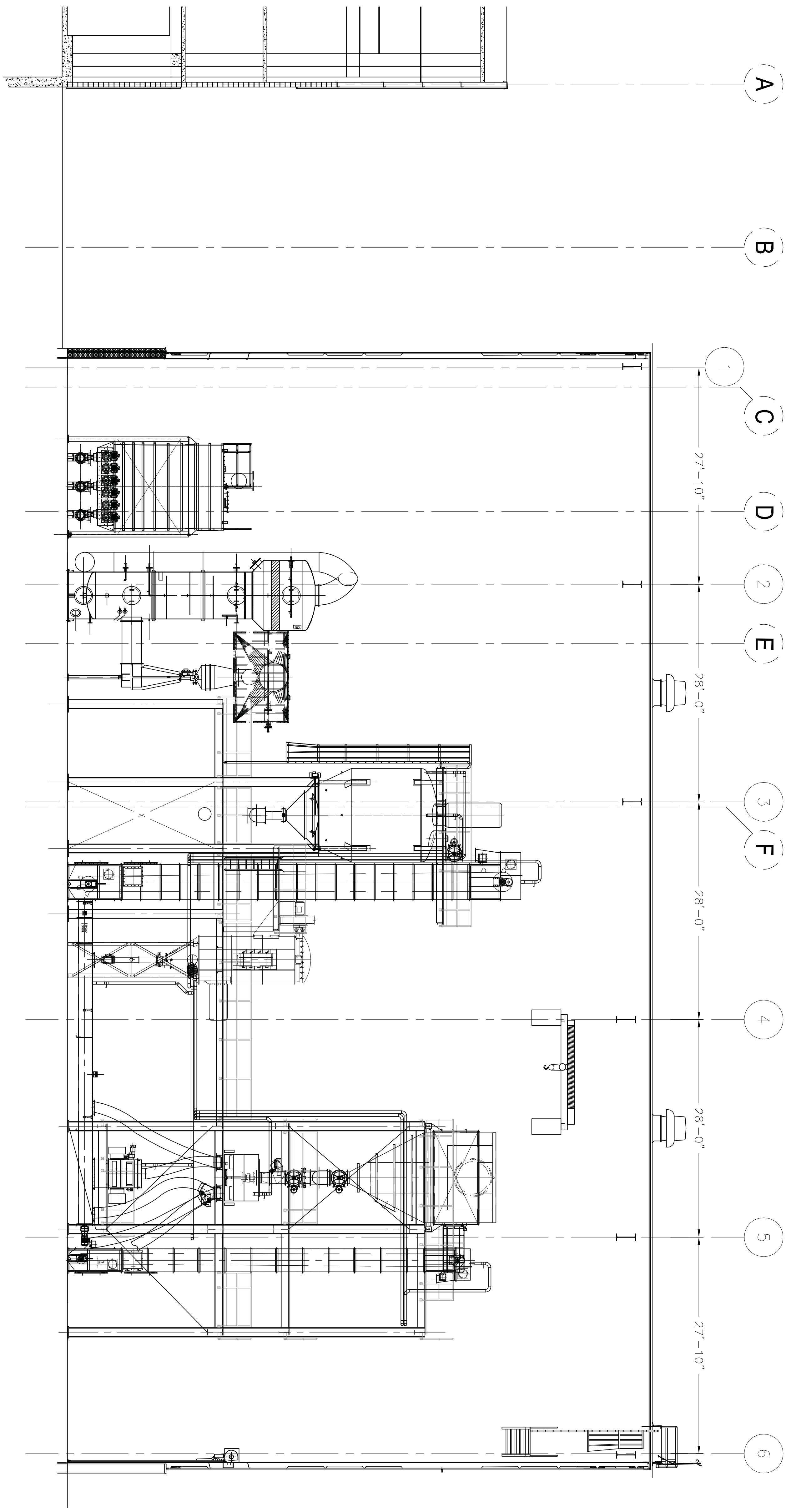

SECTION B
1/8"=1'-0"

JOB NAME	DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792
TITLE	DRYER AREA SECTION B-B
PROJECT NUMBER	1194879-1
DRAWING NUMBER	ME-302
REV	2
SHEET	1 OF 1
DRAWN BY:	DAN
DATE:	9/15/09
CHECKED BY:	
APPROVED BY:	
SCALE:	1/8"=1'-0"
FILE	ME302
SIZE	110X

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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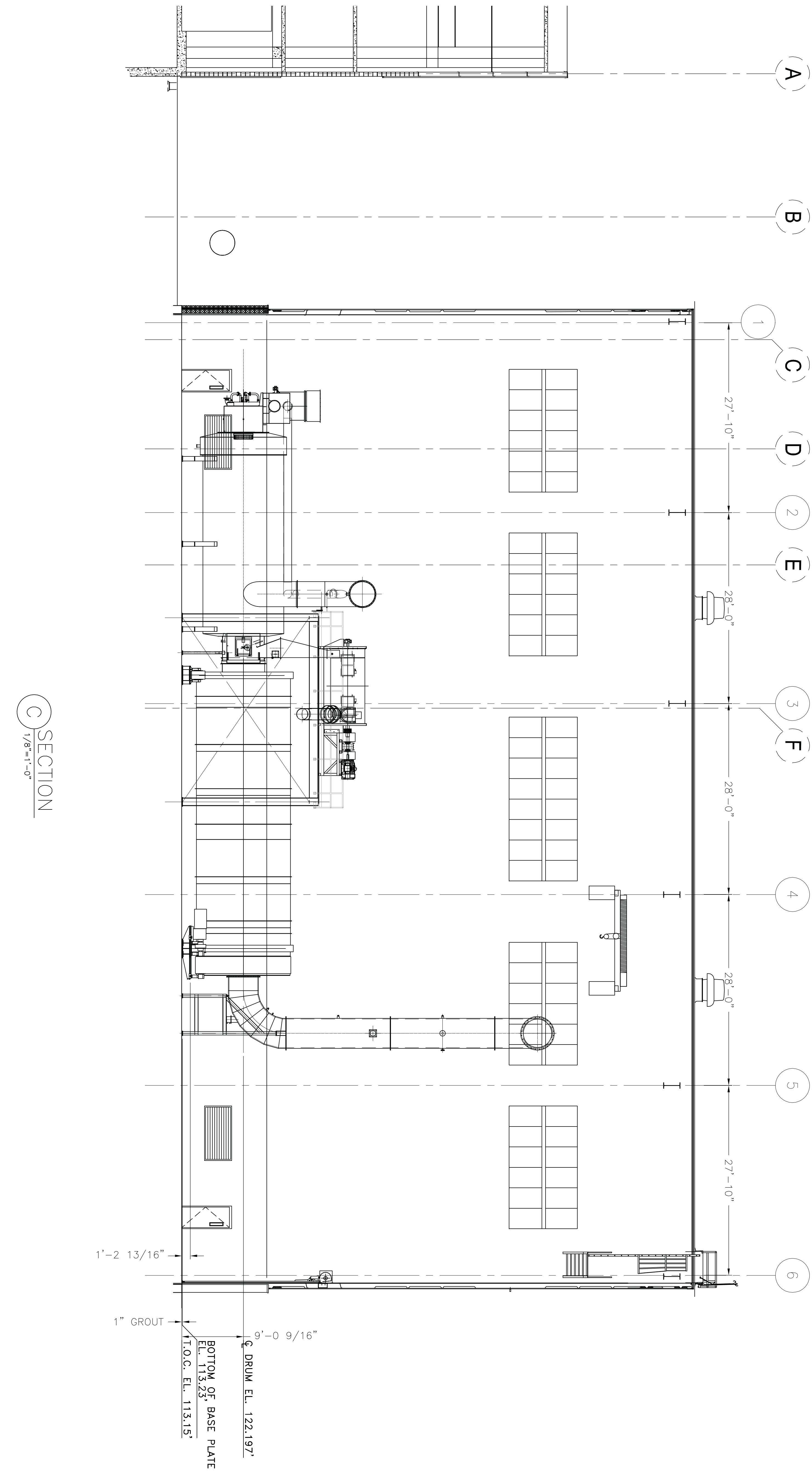

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JOB NAME	DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792	DRAWN BY: DAN	DATE: 9/15/09
PROJECT NUMBER 1194879-1		CHECKED BY:	DATE:
DRAWING NUMBER ME-303 REV 3	TITLE	APPROVED BY:	DATE:
SHEET 1 OF 1	DRYER AREA SECTION C-C	SCALE: 1/8"=1'-0"	FILE ME303
		SIZE 110X	

REV	REVISION	DATE
3	DEM AS BUILT	03/23/12
2	UPDATED FLOOR AND DRUM ELEVATIONS	10/19/10
1	GENERAL REVISIONS	8/23/10

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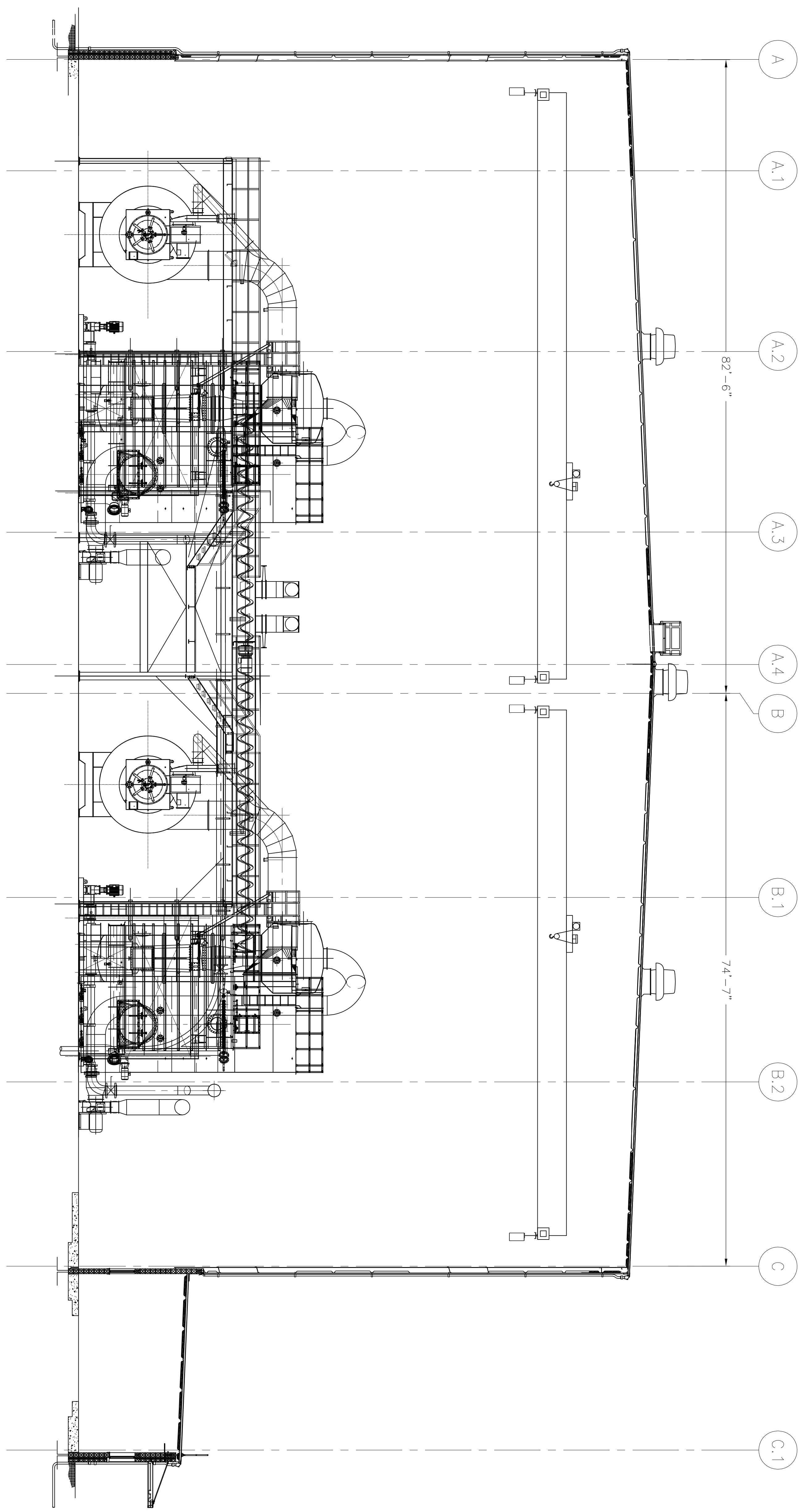
SECTION E
1/8"=1'-0"



JOB NAME	DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792
TITLE	DRYER AREA SECTION D-D
PROJECT NUMBER	1194879-1
DRAWING NUMBER	ME-304
REV	2
SHEET	1 OF 1
DRAWN BY:	DAN
DATE:	9/15/09
CHECKED BY:	
APPROVED BY:	
SCALE:	1/8"=1'-0"
FILE	ME304
SIZE	110X

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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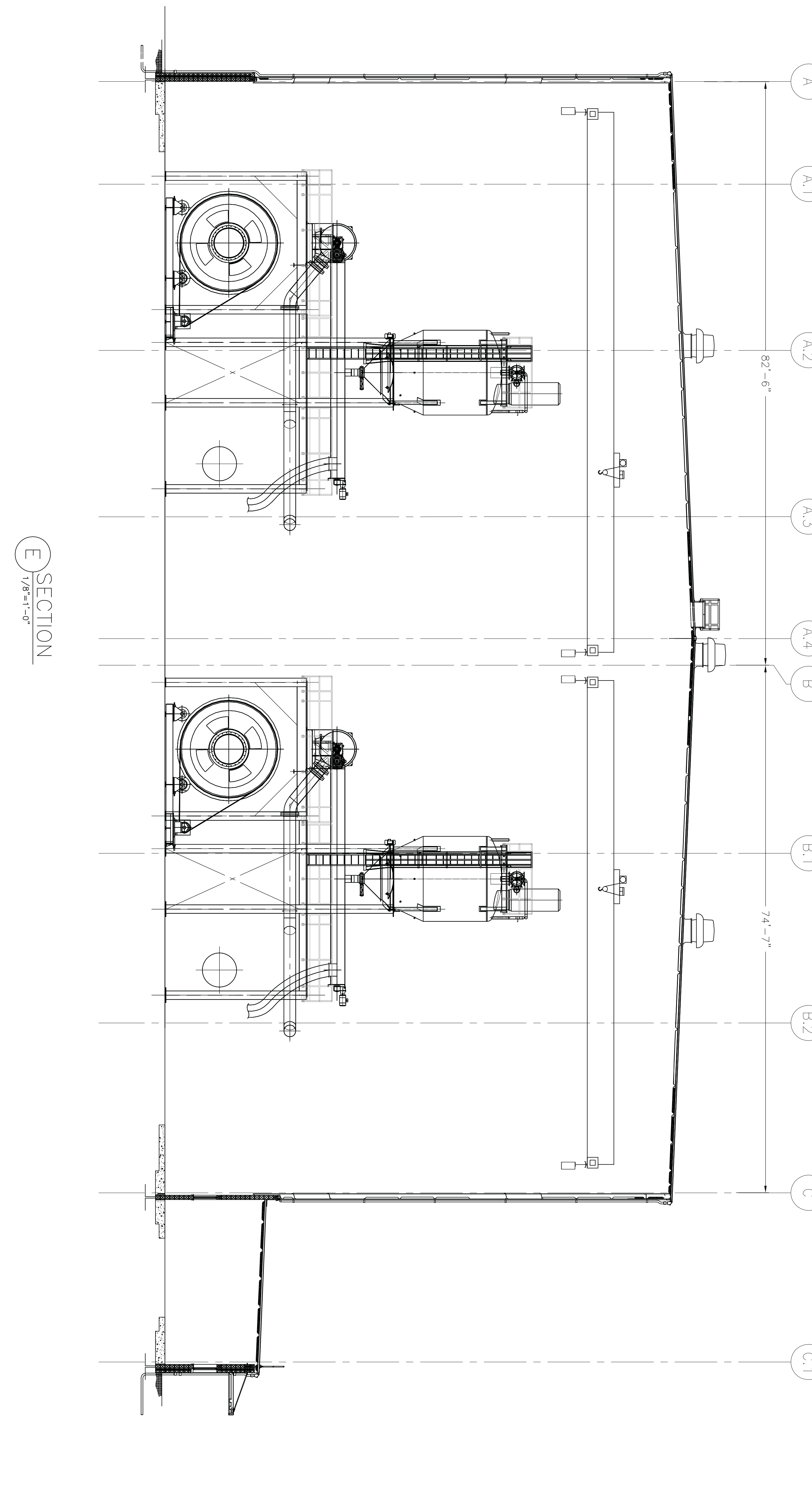

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		APPROVED BY:	DATE:
TITLE	DRYER AREA SECTION E-E	SCALE: 1/8"=1'-0"	FILE ME305
		SIZE 110X	

PROJECT NUMBER 1194879-1
DRAWING NUMBER ME-305 REV 2
SHEET 1 OF 1

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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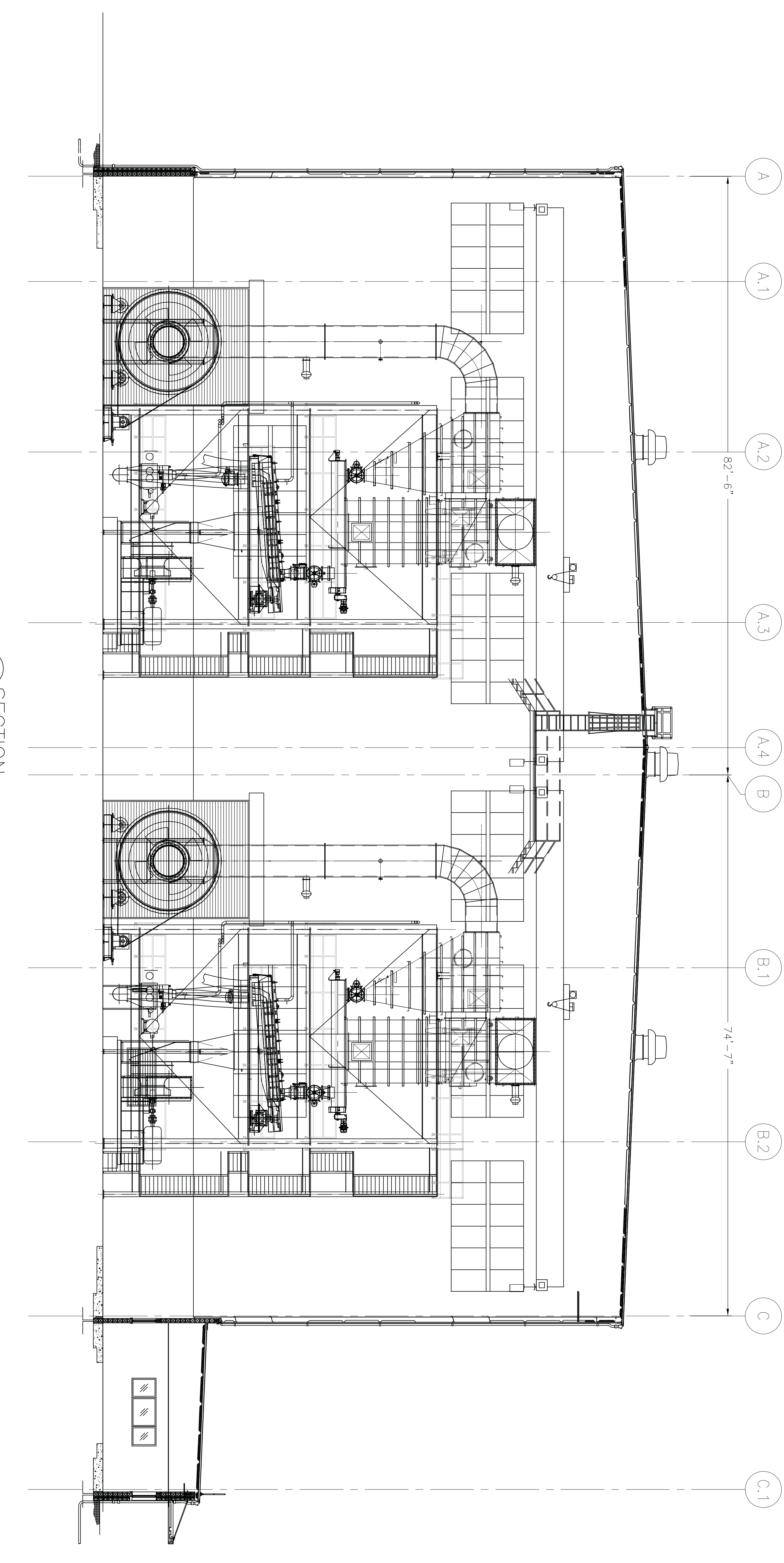

REVIEWED FOR CONSTRUCTION

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DRAWING NUMBER ME-306		CHECKED BY:	DATE:	
REV 2	TITLE: DRYER AREA SECTION F-F	APPROVED BY:	DATE:	
SHEET 1 OF 1		SCALE: 1/8"=1'-0"	FILE ME306	
		SIZE 110X		

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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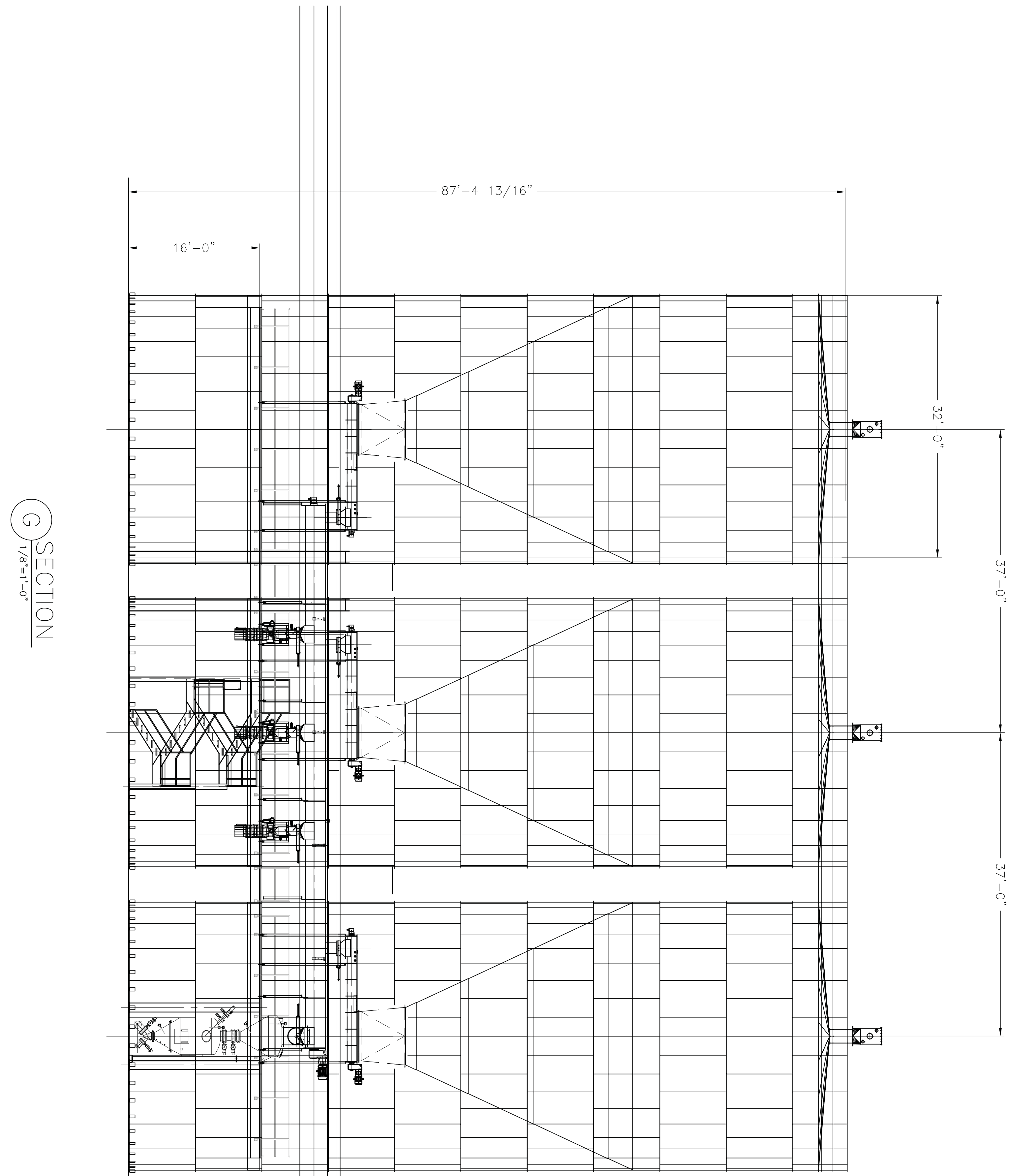

PROJECT NUMBER 1194879-1	JOB NAME DETROIT WATER AND SEWAGE DEPARTMENT DETROIT PC-792	DRAWN BY: DAN	DATE: 4/14/09		
DRAWING NUMBER ME-307		CHECKED BY:	DATE:		
REV 2	TITLE SILO AREA SECTION G-G	APPROVED BY:	DATE:		
SHEET 1 OF 1		SCALE: 1/8"=1'-0"	FILE ME307		
		SIZE 110X			

REV	REVISION	DATE
2	OEM AS BUILT	03/23/12
1	GENERAL REVISIONS	8/23/10

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7. ANDRITZ NORTH AMERICAN REFERENCE LIST

ANDRITZ is the world's largest and most prolific biosolids drying system provider to municipalities and third party operators. A brief chronology:

- 1974 – TCW Engineering GmbH designed and supplied its first Rotary Drum Drying System (DDS) to the City of St. Gallen, Switzerland.
- 1990 – TCW, now with 25 reference sites is acquired by ANDRITZ. The fundamental process design and layout concept was well established and successfully implemented at many notable sites, including Zurich, Gyor and Bremen.
- 1994 – ANDRITZ places a DDS-40 Rotary Drum Drying System into service at Waco, TX. The plant still operates today, and in 2011 an enhanced design was placed into service.
- 1994 – 2000 – A number of technology enhancements were incorporated including furnace configuration, drum detail design, screen and roller mill selection and sizing, mixer sizing increase and relocation to above the furnace head inlet, pellet cooling, transport and storage and automation/instrumentation, safety enhancements.
- 1998 – present – Single DDS train evaporation capacity was increased incrementally to DDS-70 (Jacksonville 1998), DDS-90 (Louisville 2000), DDS-110 (Singapore 2001) and DDS-1120 (Philadelphia 2008).
- 1994 – present – Safety systems have been enhanced to include explosive dust suppression at (Amherst 1994), explosion venting (Jacksonville 2000), spark detection (Philadelphia 2009), control logic (continuous), Advanced Burner Inertization System (ABIS) 1998.
- 1994 – present – ANDRITZ has delivered over 130 biosolids drying facilities of which seventy (70) are Rotary Drum Drying Systems (DDS) (see full reference list attached).
- In 1994, ANDRITZ delivered its first North American DDS at Waco, TX. Since then a total of 108 dryer plants, with a total of 32 DDS trains have been delivered in North America. All of these DDS plants are processing municipal sludge, both digested and undigested blends. (see North American reference list Tab 6.0 a) enclosed).
- More than one hundred thirty (130) separate dryer installations are in operation or under construction throughout the world many of which have multiple dryer trains.
- In excess of sixty six (66) dryers have a water evaporation rate of 8,800 pounds/hour (4,000 kg/hour) or greater.
- ANDRITZ has extensive experience in building direct fired Rotary Drum Dryers with our first installation being commissioned in St. Gallen, Switzerland in 1974, a DDS 40 (4,000 kg/hour evaporation).
- The first installation in the USA was commissioned in 1995 at Waco, TX (1 x DDS 40) and since then we have installed or are constructing Drum Drying Systems at twenty-seven locations.
- The ANDRITZ Texas based dryer system engineering team, would be responsible for delivering the project for UOSA. The majority of the ANDRITZ team has been together since Waco (1992) and is arguably the most experienced engineering team involved in direct fired drum drying, not only in the USA, but also in the world. This team focuses entirely on delivering drum drying systems and their depth of experience and expertise is vital in delivering a quality system on schedule and fitting the needs of each specific project site.

- In spring 2012, ANDRITZ commissioned the largest drum drying plant in North America, a dual DDS 110X drum drying system for the City of Philadelphia, as a direct supplier to Synagro.

- ANDRITZ is currently supplying Drum Drying Plants to Irvine Ranch, CA and Hamilton, Ontario, and a Fluid Bed Drying Plant to Capital. Regional District, Victoria, BC.

#	Award	Client	Plant Location	Type	Evap. Capacity kg/hr H20
38	2019	Synagro	City of Fort Worth, TX	DDS	1x14,000
37	2018	City of Stevens Point, WI	City of Stevens Point, WI	GPD	1x2000
36	2017	Synagro/Maple/Bird JV	Capital Regional District, Victoria BC	FDS	1x6000
35	2017	Harbour City Solutions	Hamilton, ON	DDS	1x7000
34	2013	City of St. Joseph, MO WWTP	St. Joseph, MO	BDS	1x2000
33	2012	City of Cape Girardeau	Cape Girardeau, MO	BDS	1x1500
32	2012	Shamokin Coal Township Joint Sewer Authority	Shamokin, PA	BDS	1x1000
31	2012	Milton Water Regional Sewer District	Milton, PA	BDS	1x1000
30	2011	Irvine Ranch Water District	Irvine, CA	DDS	1x5000
29	2011	Upper Occoquan Sewage Authority	Centreville, VA	DDS	1x4000
28	2010	City of Tallahassee	Tallahassee, FL	DDS	1x5000
27	2009	City of Shelton, WA USA	Shelton, WA	BDS	1x900
26	2009	Synagro Technologies Inc. for City of Philadelphia	Philadelphia, PA	DDS	2 ea. x12,000
25	2009	City of Waco Texas, USA	Waco, TX	DDS (refurbishing)	1x4000
24	2009	City of Camas, WA	Camas, WA	BDS	1x600
23	2006	Manatee County	Bradenton, FL	DDS	1x6000
22	2006	CH2M-Hill Constructors Inc.	Stamford Water Pollution Control Authority, CT	DDS	1x4000
21	2005	Archer Weston/EarthTech Joint Venture	Nashville and Davidson County, TN	DDS	2x8000
20	2005	City of Houston, TX	Almeda Sims WWTP	DDS	2x8000
19	2005	Archie Elledge Wastewater Treatment Plant	Winston – Salem, NC	DDS	1x6000

#	Award	Customer	Plant Location	Type	Evap. Capacity kg/hr H20
18	2005	Hillsborough County	Tampa, FL	DDS	2x5000
17	2004	Encina Water Pollution Control Facility	Carlsbad, CA	DDS	1x4000
16	2004	Bonita Springs Utilities	Bonita Springs, FL	DDS	1x2000
15	2004	Pierce County	Pierce, WA	DDS	1x2000
14	2004	Town of Cary	Cary, NC	DDS	1x4000
13	2002	Synagro Technologies Inc. for Sacramento WWTP	Sacramento, CA	DDS	1x4000
12	2002	Synagro for Pinellas County Utilities	St. Petersburg, FL	DDS	1x4000
11	2002	Synagro Technologies Inc. for City and County of Honolulu	Honolulu, HI	DDS	1x4000
10	2000	Northshore Sanitary District NSSD	Waukegan, IL	FDS	1x5800
9	2000	JEA	Jacksonville, FL	DDS	1x7400
8	2000	Louisville & Jefferson Counties MSD	Louisville, KY	DDS	4x8500
7	2000	Town of Leesburg	Leesburg, VA	DDS	1x2000
6	1999	Aiken County Public Service Authority	Aiken, SC	DDS	1x4000
5	1996	Amherst Wastewater Treatment Plant	Amherst, NY	DDS	1x2000
4	1996	City of Poughkeepsie, NY	Poughkeepsie, NY	Disc Dryer	1x1370
3	1996	Sumter Wastewater Treatment Plant	Sumter, SC	DDS	1x4300
2	1995	Ocean County Utility Authority	Bayville, NJ	DDS	2x4000
1	1994	Brazos River Authority	Waco, TX	DDS	1x4500

Legend

DDS = Drum Dryer

FDS = Fluid Bed

BDS = Belt Dryer

8. LITERATURE

ANDRITZ Drum Drying System DDS

North American Bio-solids Facility Tour

DDS 40 located Pinellas County, FL – In service since 2004 (operated by Synagro)

DDS 20 located Pierce County, WA – In service since 2004

- *Produces desirable, quality beneficial use product for the agricultural /fertilizer market segments*
- *Proven in over 25 years of operating experience*
- *Meets 503 reg. for pathogen reduction and vector attraction*
- *Gas recirculation for safe operation and the most cost effective emission control*
- *Technology enhancements focusing on energy consumption reduction/ alternative fuels*
- *Highly experienced delivery team*

Drum Drying System DDS


DDS 40 in Aiken, SC - In service since 1997


DDS 60 in Winston-Salem, NC - In service since 2005


DDS 40 in Encina, CA - In service since 2005


2 x DDS 120 in Philadelphia, PA - In service since 2012


DDS 20 in Bonita Springs, FL - In service since 2005


DDS 40 in Cary, NC - In service since 2004

ANDRITZ Separation

4 x DDS 100S in Louisville, KY - In service since 2002

2 x DDS 80 in Houston, TX - In service since 2008

DDS 50 in Tallahassee, FL - In service since 2012

DDS 40 in Honolulu, HI - In service since 2004

DDS 40 in Stamford, CT - In service since 2008

DDS 20 in Leesburg, VA - In service since 2000

ANDRITZ Separation

Integrated dewatering and drying, Nashville, Tennessee

Integrated dewatering and drying, Ocean County, NJ

Regional Drying Plant Manatee County, Bradenton, FL

Integrated dewatering and drying facility, Sacramento, CA

ANDRITZ designs and builds dewatering and drying facilities around the world, with 35 facilities in North America. ANDRITZ can provide equipment supply only or complete design or build services as required.

For more information:

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+1 (817) 465-5611

Peter Commerford
Manager, Drying System
peter.commerford@andritz.com
+1 (817) 419-1719 (office)
+1 (817) 271-2855 (cell)

Tracy Chouinard

To: Commerford Peter
Subject: RE: Andritz quote for EBMUD

Final Product Storage
For a total of 25,000 tons per year dry solids, 4 months storage at 95% DS and 40 lbs/ft3 requires a total silo storage working volume of 438,000 ft3.
At Fort Worth, for which I have cost data, we have a silo with a working volume of 35,000 ft3 (28'dia. X 100' eave height (drive through) – you would need twelve (12) of these – where you going to put them?
Budget Price $13, 750,000 DDP East Bay MUD project site
Scope:

- 12 Product storage silos nominal 700 ton each at 40 lbs/ft3, drive through, bolted steel erection on site by GC
- Live bottom twin screws with gates
- Truck loading spouts with dust control baghouses
- Nitrogen generation skids
- Instrumentation and controls including local truck load-out panels, Level and temperature monitoring with CO detection
- Turnover capability including screw conveyors and bucket elevators

Let me know
Thanks
Peter

From: Tracy Chouinard <tchouinard@BrwnCald.com>
Sent: Thursday, June 4, 2020 9:19 AM
To: Commerford Peter <Peter.Commerford@andritz.com>
Cc: Natalie Sierra <nsierra@BrwnCald.com>
Subject: RE: Andritz quote for EBMUD

NON-ANDRITZ SOURCE: BE CAUTIOUS WITH CONTENT, LINKS OR ATTACHMENTS.

Hi Peter,

I hope you are well. I was checking in to see if you were able to create the cost estimate for the EBMUD with 4 months of storage silos?

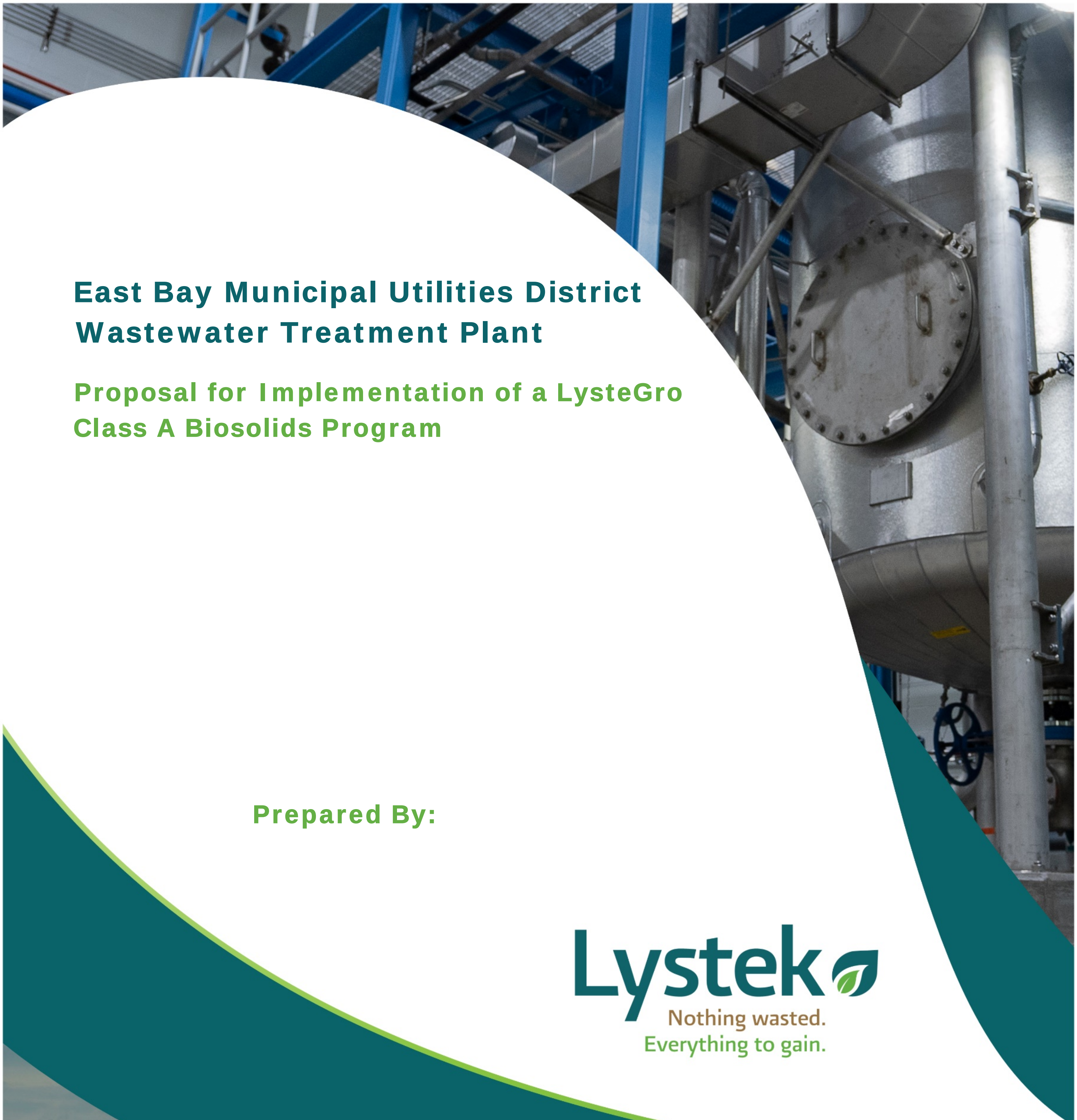
Thank you,
Tracy

From: Tracy Chouinard
Sent: Wednesday, May 20, 2020 14:23
To: Commerford Peter <Peter.Commerford@andritz.com>
Cc: Natalie Sierra <nsierra@BrwnCald.com>
Subject: RE: Andritz quote for EBMUD

Hi Peter,

Do you have a cost for the proposed 4 months of storage?

Thanks,
Tracy



East Bay Municipal Utilities District Wastewater Treatment Plant

Proposal for Implementation of a LysteGro Class A Biosolids Program

Prepared By:

Lystek
Nothing wasted.
Everything to gain.

Lystek
Nothing wasted.
Everything to gain.

East Bay Municipal Utilities District Wastewater Treatment Plant

Proposal for Implementation of a LysteGro Class A Biosolids Program

Prepared For:

Tracy Chouinard, PhD, PE

Associate Environmental Engineer
Brown and Caldwell

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Prepared By:

Lystek International Limited.

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Contact Person:

Jim Dunbar, PE

General Manager; Fairfield OMRC
Business Development Manager, Lystek International Ltd.

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E: jdunbar@lystek.com

Submitted: April 6, 2020

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1 INTRODUCTION

We understand the East Bay Municipal Utilities District (EBMUD) is interested in developing alternatives for their residual management program to alleviate current liabilities associated with diminishing off-site management options, increasing costs, and impending regulations. Potential alternatives could include advanced technologies and higher-value beneficial use programs for final products. This document proposes a cost-effective solution with an understanding that EBMUD is updating the biosolids master plan with these goals in mind.

We propose integrating Lystek THP at the EBMUD Wastewater Treatment Plant (WWTP) to produce a high-solids liquid Class A biosolids fertilizer onsite. This technology will provide EBMUD with long-term security for residuals management and diversify markets for final product use. In the coming years, new regulations will limit or prohibit currently available biosolids management options, and the offsite options that remain will be increasingly costly. With this technology, EBMUD has the opportunity to become a regional leader with an onsite solution and forward-thinking Class A biosolids fertilizer program that is sustainable, offers long-term security, and greatly reduces the risks posed by diminishing alternatives.

We are excited to offer our proven Thermal Chemical Hydrolysis Process: Lystek THP®. This technology leverages an innovative and proprietary combination of chemical, thermal, and physical processes to transform biosolids into a high-solids liquid Class A biosolids fertilizer, LysteGro®, at low life cycle costs compared to alternatives. The Lystek THP technology has a small footprint and is modular and scalable for seamless future expansion.

Our approach and technology represents a proactive leading edge solution that meets and exceeds all current regulations. Lystek THP provides security with a final, high-quality product with multiple uses and a proven record of acceptance and demand in the regional agricultural market. As traditional biosolids uses become limited or restricted, the acceptance of a Class A material meeting Federal and State standards as a fertilizer product will be very beneficial to both EBMUD and end-user farmers and ranchers.

We are also happy to offer our comprehensive LysteGro management service including product marketing and best practice use to provide EBMUD with program stability and peace of mind.

The details of this solution, including equipment quotation, operating parameters, conceptual layouts, and a product management offering, are described below.

One System.
Multiple Benefits.

- ✓ Onsite treatment
- ✓ Production of a Class A high-value biosolids fertilizer, LysteGro®
- ✓ Modular and scalable, easily expanded for increased capacity
- ✓ Easy-to-operate and maintain
- ✓ Proven and reliable technology
- ✓ Full-service product management and marketing services for the LysteGro fertilizer program
- ✓ Financial stability with predictable expenses over a long-term period
- ✓ Reduces regulatory and market liabilities

2 ABOUT LYSTEK

Lystek is a multi-award-winning company, with locations in the United States and Canada. We provide a patented, multiple benefit thermal hydrolysis solution, Lystek THP®, for biosolids and organics management. We work in partnership with municipalities, wastewater treatment plants, and private sector clients to recover valuable nutrients from biosolids and other organic feedstocks.

Co-founded in 2000 by industrial microbiologists at the University of Waterloo, Lystek THP was piloted at full-scale at the City of Guelph Wastewater Treatment Plant (WWTP) in 2004.

Our first commercial full-scale facility became operational at the City of Guelph WWTP in 2008 and we have experienced substantial growth since that time. The Lystek THP technology is now operational across eleven installations. These facilities service a range of small, medium, and large communities throughout North America, including two large regional facilities we own and operate.

Lystek's Proven Deployments:

Total: 11
US: 3
Regional DBO: 2

Our flagship facility in the U.S. is located at the Fairfield-Suisun Sewer District (FSSD) in California. Commissioned in 2016, this regional facility processes anaerobically digested biosolids from the FSSD and also receives digested and undigested third-party material from outlying communities such as San Francisco, Benicia, Petaluma, Santa Rosa, and Palo Alto. As a regional facility, the Lystek Fairfield Organic Materials Recovery Center (OMRC) has a total operating capacity of 150,000 wet tons annually.

We provide resource recovery solutions to over 40 municipalities across North America.

See Appendix A for a summary of our installations and Appendix B for example case studies in Fairfield, CA and St. Cloud, MN.

Our process and existing deployments in both the U.S. and Canada have been honored with numerous regional, national, and international awards.

For a list of our awards and honors, see Appendix C.

We are fully committed to ongoing research and development. We collaborate with various organizations like WERF LIFT, municipal and industrial research laboratories, academic institutions such as University of California Davis, Purdue University, Manhattan College, University of Guelph, Western University, and University of Waterloo, among others.

Our management team offers proven national and international experience in the wastewater, organics, and waste management industries. See Appendix D for an overview of the expertise our team can offer EBMUD.

The Tomlinson Group of Companies has owned Lystek since 2011. The Tomlinson Group has been a successful company for over 60 years within the same family ownership. Tomlinson's divisions deliver more than $300,000,000 in projects annually, which provides Lystek with a reliable and financially stable basis.

We are committed to long-term partnerships with our customers and leverage our expertise to offer our comprehensive technology, design-build, product management, and communications and engagement support.

3 PROPOSED LYSTEK SOLUTION FOR EBMUD WWTP

The EBMUD WWTP utilizes conventional treatment to meet water quality effluent standards and anaerobic digestion for residual solids treatment.

EBMUD is updating their biosolids master plan and considering alternatives for biosolids management, including conversion of Class B material into a higher-quality Class A product. Key goals for this transition include: provision of comprehensive end-product management options and enhanced certainty of end-user market demand. EBMUD also sees the benefits of multi-year planning certainty for its biosolids beneficial use program, avoiding the uncertainties and price impacts from current year-to-year biosolids options.

In light of this, we propose a progressive implementation of an on-site solution to manage and convert existing dewatered biosolids cake into a high-value Class A biosolids fertilizer: LysteGro. EBMUD has the capability to employ existing space at its wastewater treatment plant to accommodate compact operating equipment and storage infrastructure. In doing so, EBMUD will enhance its existing onsite dewatering program with biosolids treatment and storage infrastructure.

This proposed solution has been developed using the assumptions noted in Table 3-1.

*We propose between one and three **LY10 THP Modules** with varying operating hours required, as outlined in Table 3-1, to meet the projected needs of the EBMUD WWTP.*

3.1 PROJECT BENEFITS

Lystek THP will achieve multiple benefits at the EBMUD WWTP:

- Onsite treatment and conversion of biosolids into a Class A high-value biosolids fertilizer, LysteGro
- Modular and scalable, enabling progressive implementation of operating equipment to meet increased capacity needs easily
- Operations security with existing staff; no disruptions to current wastewater operations
- Easy-to-operate technology with no additional operator certification requirements
- Proven and reliable operating technology with regional access to back-up systems (i.e., Lystek's Fairfield OMRC)
- Partnership with Lystek on the LysteGro fertilizer program
- Financial stability with predictable expenses over a long-term period
- Readily available local operating support and parts inventory

Table 3-1 Project Assumptions

	2030**	2050**
100%*		
Predicted biosolids generation rate (2030):	24,291 dry ton/year	30,321 dry ton/year
Operating hours per year:	8,736 (24 hours/day, 7 days/week)	
LysteGro Class A fertilizer per year:	38,800,000 USG (assumed 15% solids)	48,500,000 USG (assumed 15% solids)
LY10 Modules recommended:	3 LY10s	1 additional
75%*		
Predicted biosolids generation rate (2030):	18,218 dry ton/year	22,741 dry ton/year
Operating hours per year:	6,864 (24 hours/day, 5.5 days/week)	8,736 (24 hours/day, 7 days/week)
LysteGro Class A fertilizer per year:	29,100,000 USG (assumed 15% solids)	36,300,000 USG (assumed 15% solids)
LY10 Modules recommended:	3 LY10s	*extended operating hours
50%*		
Predicted biosolids generation rate (2030):	12,146 dry ton/year	15,160 dry ton/year
Operating hours per year:	6,864 (24 hours/day, 5.5 days/week)	8,736 (24 hours/day, 7 days/week)
LysteGro Class A fertilizer per year:	19,400,000 USG (assumed 15% solids)	24,200,000 USG (assumed 15% solids)
LY10 Modules recommended:	2 LY10s	*extended operating hours
25%*		
Predicted biosolids generation rate (2030):	6,073 dry ton/year	6,073 dry ton/year
Operating hours per year:	7,488 (24 hours/day, 6 days/week)	8,736 (24 hours/day, 7 days/week)
LysteGro Class A fertilizer per year:	9,700,000 USG (assumed 15% solids)	12,100,000 USG (assumed 15% solids)
LY10 Modules recommended:	1 LY10	*extended operating hours

**Assumes proportion of annual flow*

***Assumes no peaking factor (sizing based off average TSS/day provided), peaking to be managed by extended operating hours where applicable, a redundant module, or alternate management option*

3.2 LYSTEK THP®

The Lystek Thermal Hydrolysis Process (Lystek THP) is a unique, thermal-chemical hydrolysis process employing high-speed shearing, alkali, and low-pressure steam injection. The technology has the ability to process digested or undigested organic feedstocks to produce a multi-purpose, hydrolyzed product.

Lystek THP provides operational flexibility. Lystek THP and the multiple product uses, including **LysteGro®** Class A biosolids fertilizer, **LysteMize®** digester enhancement option, and **LysteCarb®** alternative carbon source, and the benefits associated with implementing this system and our comprehensive service offering are outlined in Appendix E.

For a comparison of the differences and similarities between Lystek THP and alternative Class A biosolids processing and management options see Appendix F.

3.3 INTEGRATION OF THE LYSTEK MODULE

We propose the Lystek THP Module is incorporated downstream from the existing dewatering equipment at the EBMUD WWTP (process flow schematic outlined in Figure 3-1).

In order for the Lystek THP system to be cost effective and allow the plant to realize the benefits of reduced residual volumes, a dewatering step must be included upstream of the Lystek THP system. The dewatering equipment can be placed directly above the biosolids storage hopper, which reduces material handling capital and operating costs. This represents a significant avoided cost in conveyors, piping, and truck loading facilities.

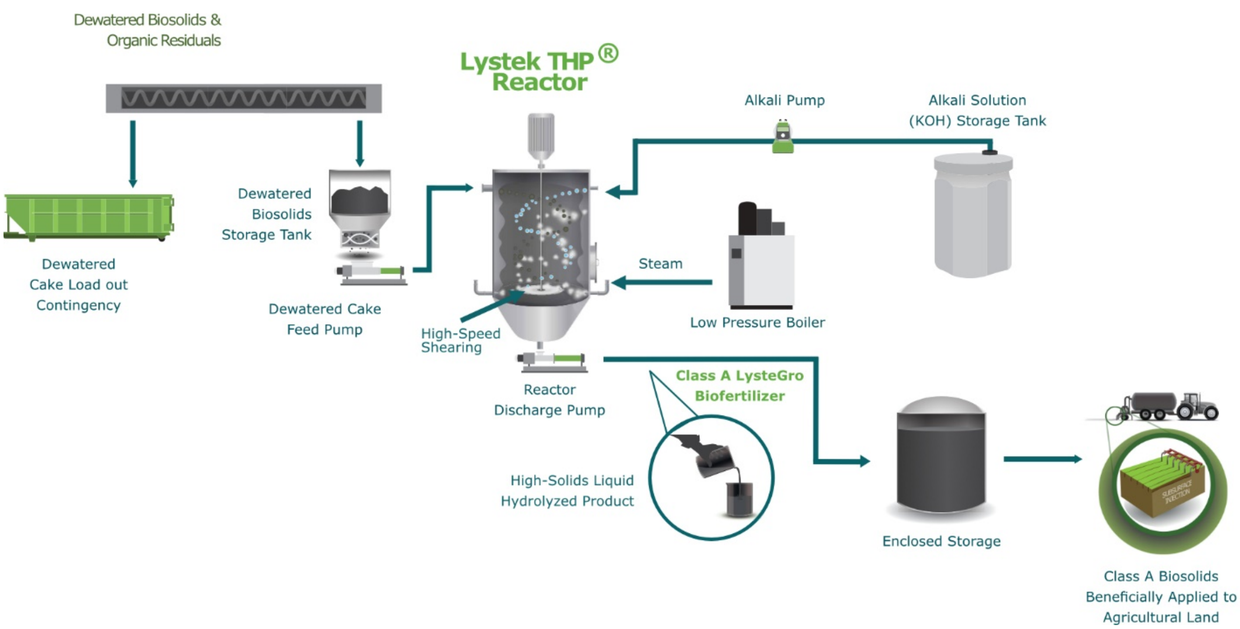


Figure 3-1 Integration of Lystek THP at the EBMUD WWTP

3.4 PROCESS DESCRIPTION

Dewatered biosolids are fed into the biosolids storage tank and then pumped using progressive cavity feed pumps into the Lystek Reactor.

Lystek THP technology requires feedstock at lower solids content compared to other Class A biosolids technologies or managing Class B cake biosolids, which results in substantial polymer cost savings by comparison. We have proven this approach in past projects with vendors such as Andritz, GEA, Alfa-Laval, and BDP as key project partners.

Within the Reactor, the combination of heat (by way of low-pressure steam injection), pH increase (using an alkali source, typically potassium hydroxide (KOH)), and physical shearing (using a high-speed mechanical blade) transform the material into a homogenized and pumpable high-solids content, liquid product. The Reactor operates at atmospheric pressure and is insulated to reduce heat loss during processing and stand-by times.

The Reactor operates in a semi-continuous mode. This means that the Reactors are regularly filled to their working capacity while steam, alkali, and shear are applied. Following the confirmation of temperature and hold criteria to meet USEPA Class A biosolids requirements, the finished product, LysteGro, is discharged to storage on a continuous operating cycle to maximize the throughput of the system. The product is stored between application seasons.

The characteristics and benefits of the LysteGro biosolids fertilizer are outlined in detail in Section 5 below along with an overview of our Product Management Services offering.

3.5 SYSTEM OPERATIONS

Due to the user-friendly and easy to operate nature of the system, minimal staff intervention is required. In most cases, existing operations staff is adequate; for larger (or complete build-out) systems, a dedicated operator is advisable to serve as the lead operations contact. This approach has been proven and confirmed throughout our existing in-plant deployments.

Note that the process is fully-automated and in typical set-ups, the operator(s) need only to monitor the system in the event of an alarm notification.

The processing parameters associated with this system are noted in Table 3-2.

Table 3-2 Estimated Processing System Operating Parameters

Electrical consumption for processing	Average 60 kW-h per dry ton
Heat requirements for processing	Average 1,100,000 BTU per dry ton[1]
45% caustic potash (liquid solution @45%)	Average 190 lb per dry ton[2]
Operating temperature set point	167°F / 75°C
Solids content – LysteGro product	13 - 16%
Viscosity – LysteGro product	6,000 – 10,000 cP

[1]Dependent upon biosolids feed temperature into the Lystek Reactor

[2]Estimated based on average dosing rates for digested feedstock

Further information detailing the operating inputs of the Lystek THP solution can be found on the attached Technical Specifications Sheet, provided as Appendix G.

3.6 MAJOR EQUIPMENT LIST

We recommend one LY10 Lystek THP Modules to meet 25% of EBMUD's projected average 2030 biosolids processing needs with operations up to twenty-four hours per day, seven days per week. Should the Utility be interested in treating a greater proportion of their dewatered biosolids volume, we recommend additional Modules be installed as outlined in Table 3-1.

As an added note, with a thorough understanding of EBMUD's needs and goals for operational redundancy, Lystek can offer available capacity at the Fairfield-OMRC facility in times of need. This could offer substantial capital savings by reducing the need for back-up equipment.

Each Module includes the Lystek THP Reactor as well as the associated pumps, tank, and supporting auxiliary systems.

Listed below in Table 3-3 is the major elements associated with the proposed system.

Table 3-3 Proposed Equipment List for each LY10 Module

Element	Quantity	Function
Dewatered Biosolids Storage Tank	1	Receives and stages dewatered biosolids from dewatering equipment for processing within the Reactor
Dewatered Biosolids Feed Pump	1	Progressive cavity pump feeds the Reactor
Lystek THP Reactor and Disperser	1	Transforms biosolids into Class A LysteGro biosolids fertilizer
Reactor Discharge Pump	1	Positive displacement pump transports LysteGro fertilizer from the Reactor to the LysteGro Storage
Alkali Storage Tank	1	Double walled storage tank to store alkali
Alkali Pump	1	Doses alkali to Reactor
Boiler	1	Low pressure boiler (<15 PSI) provide steam heat to the Reactor

With multiple Modules, we recommend installing the above noted equipment in parallel with the exception of the alkali storage tank, where one or two larger tanks can be used to supply all Modules if desired. Parallel Modules provides additional redundancy and security to EBMUD.

Additionally, we understand that the WWTP currently produces excess biogas on site. To capitalize on this site resource, we propose installing a dual fuel boiler as a part of the THP Module to be fueled by excess biogas when available. This will enhance the sites use of recovered resources and reduce operating costs.

3.7 FACILITY LAYOUT

A conceptual facility layout has been included to demonstrate the compact and modular nature of the Lystek THP system. Layouts for single, double, and triple parallel LY10 Modules are included in Appendix H.

Note that this layout is a conceptual starting point, and can be adapted to alternate geometries in order to suit the available real estate. We have experience integrating our system with different types of dewatering equipment as well as with both new builds and retrofitting existing infrastructure to accommodate the overall footprint.

The overall footprint ranges from an average of approximately 1,500 to 3,300 square feet for one to three LY10 Modules respectively.

3.8 PRODUCT STORAGE

Once the biosolids have been processed and transformed into LysteGro they are then pumped into enclosed storage. Once there, material is stored in a contained environment in order to ensure a quality product for our agricultural customers. We have experience with above or below ground tanks, steel or concrete, as well as lined and covered reservoirs. We would be happy to discuss these options in relation to optimized operations and available site infrastructure.

Given the land app seasonality typical for the region, we recommend the installation of a minimum of four months storage on site to offer EBMUD further program security.

Recommended minimum storage volumes for each estimated scenario are outlined in Table 3-4 below.

Table 3-4 Recommendations for Installed Liquid Storage Capacity.

	2030**	2050**
100%*		
Annual LysteGro production:	38,800,000 USG	48,500,000 USG
Minimum recommended storage capacity:	13,000,000 USG	16,200,000 USG
75%*		
Annual LysteGro production:	29,100,000 USG	36,300,000 USG
Minimum recommended storage capacity:	9,700,000 USG	12,100,000 USG
50%*		
Annual LysteGro production:	19,400,000 USG	24,200,000 USG
Minimum recommended storage capacity:	6,500,000 USG	8,100,000 USG
25%*		
Annual LysteGro production:	9,700,000 USG	12,100,000 USG
Minimum recommended storage capacity:	3,300,000 USG	4,100,000 USG

The homogenous nature of LysteGro eliminates the need for any decanting, mixing, aeration, or cleanout activities in the storage tanks and the capital and operational costs associated with this.

4 LYSTEK THP QUOTATION

Based on our current understanding of the proposed EBMUD WWTP we are prepared to offer a quotation for the required equipment supply and technology licence of **US $2,525,000** per LY10 Module.

This cost accounts for the technology licence, mechanical and electrical equipment, and software associated with the Lystek THP LY10 Module and is contingent on the project assumptions. This cost does not include installation, LysteGro storage, interconnect wiring and piping, utility connections, freight, or integration of the Lystek SCADA system into the overall facility SCADA.

5 PRODUCT MANAGEMENT

Part of our strategic approach is to provide a complete, turnkey product and service offering to our customers. This includes management of the LysteGro product and all associated costs. Our team effectively manages large and small-scale LysteGro sales and application programs in the San Francisco Bay Area of California and across Canada.

Our experiences in markets across North America provide us with the expertise needed to develop and manage an effective and professional fertilizer marketing and application program for the EBMUD.

This section will provide an outline of the benefits of producing Class A biosolids and the approach we will use to manage the marketing, sales, and distribution of the product.

The Lystek THP system transforms biosolids and residuals into a Class A biosolids product that is pathogen free and in high demand.

5.1 LYSTEGRO® CLASS A BIOSOLIDS

The Lystek THP system transforms biosolids and residuals into a pathogen free, Class A biosolids product that is in high demand by the end customer. *The multi purpose product meets all criteria for Class A biosolids as classified by the US EPA.* LysteGro has also received state registration as a bulk fertilizer from the California Department of Food and Agriculture (CDFA). The combination of macro- and micronutrients and organic carbon provide a valuable cost-effective resource to customers who want an alternative fertilizer source to improve long-term soil health.

The result of the process is a valuable fertilizer with predictable Nitrogen, Phosphorus, and Potassium (NPK) values that is high in solids (13%-16%) and remains fully pumpable with conventional liquid handling and application equipment (see Appendix J for example photos).

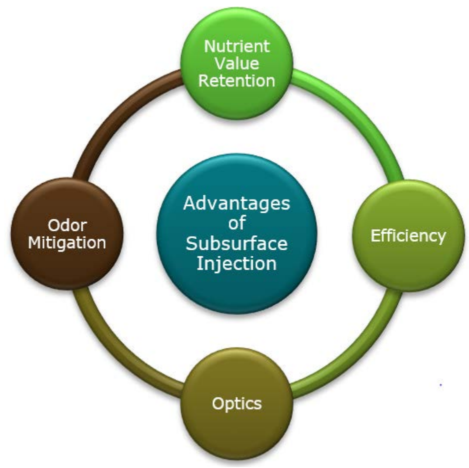
This system and our product management methods have been designed and proven to maximize the value of the product for both the end-user and manufacturer of the product.

Through the Lystek process, the inherent value in the biosolids feedstock is preserved while valuable potassium is added and pathogens are eliminated. In addition to the macronutrient value, the LysteGro product is beneficial to farmers for several reasons, specifically:

Cost Savings: We will market the material to the agricultural sector at an affordable price based on the NPK content of the material. By using the Lystek material, farmers will save on the input costs they would otherwise pay if purchasing inorganic fertilizer. They will also see multi-year value from LysteGro due to the slow release nature of the nutrients in the product and improvements in soil health.

Micronutrients: Micronutrients important for crop growth, including Calcium, Sulfur, Zinc, Copper, and several others inherent in biosolids, provide the farmer with an affordable option for these nutrients that are expensive to purchase in the commercial fertilizer form.

Organic matter: The addition of organic matter to soils will help to improve overall soil health, including improved water holding capacity, soil structure and tilth, increased microbial activity as well as increased resilience to severe weather conditions.



LysteGro is subsurface injected into the soil to ensure maximum nutrient use efficiency, limit odor concerns, and the potential for run-off. The in-field aesthetics and cleanliness of the injection operation that we employ is superior to surface application methods. The liquid nature of LysteGro allows for loading and off-loading efficiencies as well as odor mitigation at the plant and throughout transportation.

The sub-surface injection of LysteGro further increases soil contact, and reduces the risk of run-off. Additionally, because the material is concentrated, there is a reduction in the overall volume applied per acre compared with traditional liquid programs. As a result, application above the hydraulic loading rate of the soil, which can lead to leaching, is not a concern with LysteGro. The advantages of producing a high-solids liquid product and our approach to product management are described further in Appendix K.

We will work with local and regional farmers, ranchers, and contractors to haul and apply the material based on our internal best management practices.

These requirements meet state and federal regulations for Class A biosolids, and also incorporate best management practices that are standard for the agricultural industry.

The LysteGro fertilizer product has been evaluated in a number of third-party trials and university research as a part of our ongoing research and development (see Appendix L for a summary report on third-party corn trials fertilized with LysteGro). A detailed summary of this trial as well as additional trial results are available upon request.

In 2013, a Water Environment Federation (WEF) workshop report stated that *"due to concerns with pathogens and odors, there is a distinct shift away from Class B land application and towards more advanced, Class A treatment options."* It is also well known that global supplies of phosphorus, a key ingredient in the manufacture of chemical fertilizers, are being rapidly depleted. There is therefore a role for EBMUD to play in helping to ensure that organic resources, such as biosolids, are beneficially utilized for agricultural sustainability.

5.2 MARKETING AND SALES

We have developed a proven and successful marketing program for LysteGro in Northern California and across Canada. We are capable and willing to assume full responsibility for the fertilizer distribution program and are currently performing this service for the majority of our customers. *The combination of our cost-effective technology and our ability to provide back-end product management offers a turnkey service to our customers. This full service approach sets us apart from alternative technology providers.*

We have invested significant resources into developing a professional product management team and the resources required to facilitate this. We employ agricultural professionals (Certified Crop Advisors, Professional Agrologists, etc.) who have an educational background in environmental science and as a result, we understand and focus on both the needs of our agricultural customers and the importance of environmental stewardship.

We have sold over ***1,000,000 tons*** *of LysteGro in North America!*

Lystek will sell the product, which we have successfully accomplished for all of our customers and at all of our locations. To date, we have sold all LysteGro fertilizer (over 1,000,000 tons) we manage.

With commercial fertilizer prices and demand for organic amendments from the agricultural sector expected to increase, the equivalent value of the LysteGro fertilizer will continue to rise over time and have greater value to customers. This represents a built-in hedge against future rising management prices.

Over the next 20 years, these market trends will continue as society continues to prioritize resource recovery, soil health, and sustainability. Our Product Management team's strategy will include involvement with local Farm Bureau offices and approaching local agricultural groups, leaders, and innovative farmers to explain the features and benefits of the Lystek process and LysteGro product to educate and develop a stable, long term market of loyal customers.

"After my first application of LysteGro, I saw immediate results in my pasture crop as compared to my field without the product. The Lystek staff are very accommodating to my schedule and easy to work with. The application equipment used was effective and had no negative impact on my existing operation."

Ryan Mahoney, Rio Vista Rancher

In summary, our approach to product management is to ensure that the material is handled and applied in the most effective manner possible to optimize the value of the material while also engaging the local agricultural community to demonstrate and prove product value. This long-term strategy is proven to effectively develop a stable market of loyal customers who understand the value of the product and are willing to pay for it. With Lystek as its partner, EBMUD would have the option to leverage our proven successful approach or simply request our assistance, where required, to manage the product.

5.3 LYSTEGRO® MANAGEMENT FEE

Based on our initial assessment of the region and potential market for LysteGro we are prepared to offer a management fee of **US $25 - 30** per ton of LysteGro for a five-year term.

We are offering this as a preliminary price range based on our current understanding that Brown and Caldwell is evaluating multiple options for total processing volumes dedicated to Lystek. With a clearer indication of total volume dedicated to Lystek, we would be able to provide a firm price.

This full service offering includes promotion of the product at local agricultural events, and working with local farmers/ agronomists to develop a paying customer base for the LysteGro fertilizer. We are willing and able to assume responsibility for all marketing and sales of the product and management (included associated fees) of hauling and application contractors. We will ensure that all regulatory requirements are met, alongside Lystek's own best management practices.

6 SUMMARY

We thank you for the opportunity to propose a Class A, high-solids liquid, biosolids processing and management solution for the EDMUD WWTP.

This approach will enhance EBMUD's biosolids handling and management with a sustainable Class A biosolids program that will offer security and economic stability. As the Bay Area becomes more susceptible to organic management restrictions, EBMUD would be able to limit the regulatory and market liabilities associated with traditional practices. The modular and scalable nature of Lystek THP will enable EBMUD to progress towards a program that is 100% self-sustained and internally managed with longer-term certainty.

This offer also includes comprehensive product management services to develop a long-term biosolids program in the region and ensure best-practice use of LysteGro. This offers EBMUD a hands-off, worry-free, and sustainable solution.

We look forward to collaborating with EBMUD to address their biosolids management with a Class A solution that will be a model in the Bay Area. This will enhance resource recovery, operational and management efficiencies on site, and will also set the City up for a sustainable solution that can easily accommodate increased flows or regulatory changes.

Thank you for your consideration of this biosolids management option. We look forward to future discussions.

Jim Dunbar, P.E.

General Manager, Fairfield OMRC
Business Development Manager, Western US

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jdunbar@lystek.com

APPENDICES

APPENDIX A

Lystek Installations

Lystek
Nothing wasted. Everything to gain.

Design, Build, Transfer Installations

Location (Commissioned)	Pop.	Volumes Currently Processed (DT/Y) [1,2]	Site Installation Details	Module Size	Feedstock	Lystek Products/ Processes	LysteGro Storage
Guelph, ON (2008)	132,000	2,750	On-Site - Retrofit	**2 - LY6**	Anaerobic Digested Biosolids	**LysteGro, LysteMize**	Modular Transportable Above Ground Storage Tanks
St. Marys, ON (2010)	7,300	265	On-Site - Retrofit	**LY3**	Originally: Anaerobic Digested Biosolids Current: Aerobic Digested Biosolids	**LysteGro, LysteMize, LysteCarb**	Below Ground Concrete Tank
Elora, ON (2014)	7,500	145	On-Site - New Build	**LY6**	Aerobic Digested Biosolids	**LysteGro**	Below Ground Concrete Tank
North Battleford, SK (2014)	14,300	540	On-Site - Retrofit	**LY6**	Aerobic Digested Biosolids	**LysteGro**	Retrofitted Reservoir – Lined & Covered
St. Thomas, ON (2018)	41,800	1,650	On-Site - New Build	**LY6**	Undigested Residuals	**LysteGro**	Above Ground Tank
St. Cloud, MN (2018)	120,000	1,650	On-Site - Retrofit	**LY10**	Anaerobic Digested Biosolids	**LysteGro**	Repurpose - Below Ground Concrete Tank
Innisfil, ON (2019)	36,500	610	On-Site - New Build	**LY3**	Aerobic Digested Biosolids	**LysteGro**	Retrofit - Above Ground Tank with Floating Cover
Goleta, CA (2019)	N/A	Demo / R&D	On-Site - Skid Unit	N/A	Source Separated Organics (UC Santa Barbara), Biosolids (Goleta Sanitary District)	**LysteMize**	N/A

[1]Approximate current volumes processed in dry tons per year

[2]Current site processing dependent upon hours of operation and regulated processing rates

**Customer references available upon request*

Regional Installations

Location (Commissioned)	Module Size	Site Capacity (WT/Y)[1]	Site Details	Deployment Structure	Lystek Products/ Processes	Feedstock	LysteGro Storage
Southgate, ON (2012)	**3 – LY10**	165,000	Off-Site - Regional Facility, Greenfield	DBOO	**LysteGro**	Undigested / Digested Biosolids & Organics from Various Municipalities	Reservoirs – Lined & Covered
Serving generators such as: - Toronto, Halton, Hamilton, Kitchener, Guelph, Niagara, Orangeville, Tay Township, West Grey, Gravenhurst, Peterborough, Huntsville, Mississauga, Brantford, Arthur, Innisfil, Meaford, Owen Sound, Midland, Walkerton, Centre Wellington, Mono, Biox Ltd.							
Iroquois, ON (2012)	**1 – LY10**	45,000	Off-Site - Regional Facility Upgrade	DBT	**LysteGro**	Undigested / Digested Biosolids from Various Municipalities	Below Ground Concrete Tank
Serving generators such as: - Ottawa, Toronto, Peterborough, among others							
Fairfield, CA (2016)	**2 – LY10**	150,000	On-Site - P3 Regional Facility	P3 - DBOO	**LysteGro, LysteMize**	Undigested / Digested Biosolids from Various Municipalities	Reservoir – Lined & Covered
Serving generators such as: - Fairfield-Suisun Sewer District, City and County of San Francisco, East Bay Municipal Utility District, Santa Rosa, Central Marin Sanitation Agency, Petaluma, Benicia, Palo Alto, City of South San Francisco							

[1]Site capacity represented in wet tons (average 15% TS) per year

**Customer references available upon request*

APPENDIX B

Case Studies

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Retrofit Creates Sustainable Biosolids Management Solution

Fairfield-Suisun Sewer District, California

Lystek
Nothing wasted.
Everything to gain.

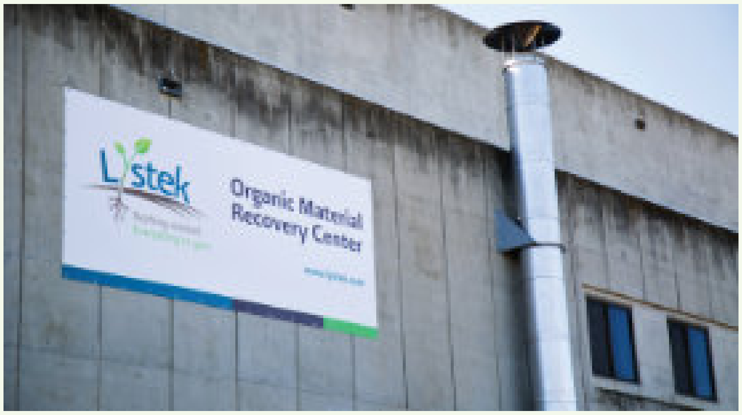
Fairfield-Suisun Sewer District enters into a unique Public-Private Partnership (P3) with Lystek to bring first, comprehensive biosolids management solution to the San Francisco Bay Area.

ABOUT

Located north-east of San Francisco, the Fairfeld-Suisun Sewer District (FSSD) serves over 135,000 and operates 70 miles of sewer with 13 pumping stations within 48 square miles in central Solano County. **www.fssd.com**

CHALLENGES

- Sensitive natural environment and tightening regulations
- Under-utilized assets/infrastructure
- Odors, pathogens, and potential run-off issues related to the historical use of Class B biosolids
- High and rising costs of historical biosolids management
- Lack of a comprehensive biosolids management solution for the Bay Area



SOLUTION

- Construction and retroft of a new state-of-the-art, 150,000 (U.S. ton) Organic Material Recovery Center (OMRC) designed, built, owned and operated by Lystek
- Conversion of Class B biosolids material into a sale-able Class A EQ biofertilizer product
- Product that can help offset rising cost of fertilizers and be stored in any suitable location
- Comprehensive air handling and process for advanced odor and vector control
- Alignment with California's Healthy Soils Initiative, the Clean Water Act and organics diversion regulations
- Unique P3 solution converting a traditional WWTP into a Wastewater Resource Recovery Center (WRRC)

RESULTS

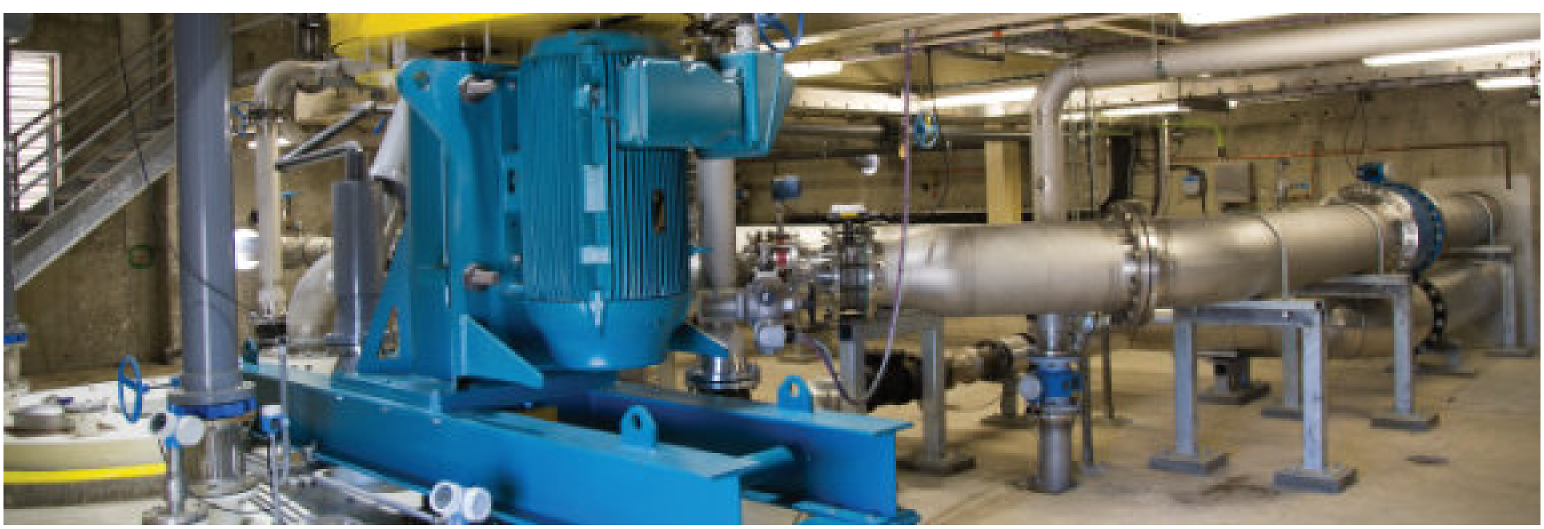
- Provides the FSSD with cost certainty in biosolids management for the next twenty (+) years
- Elimination of historical odors, pathogens, and potential run-off issues from Class B biosolids
- Opportunity to increase diversion rates for organic "waste" from Bay Area landflls
- Reduces Greenhouse Gas (GHGs) emissions and contributes to the "circular economy"
- Introduction of LysteGro®, a Class A EQ (Exceptional Quality) product, recognized by the California Department of Food and Agriculture as a licensed fertilizer

ALIGNMENT WITH PROGRAMS & POLICIES

The FSSD serves more than 135,000 residential, commercial and industrial customers, overseeing wastewater management and sanitary sewers in California's Solano County.

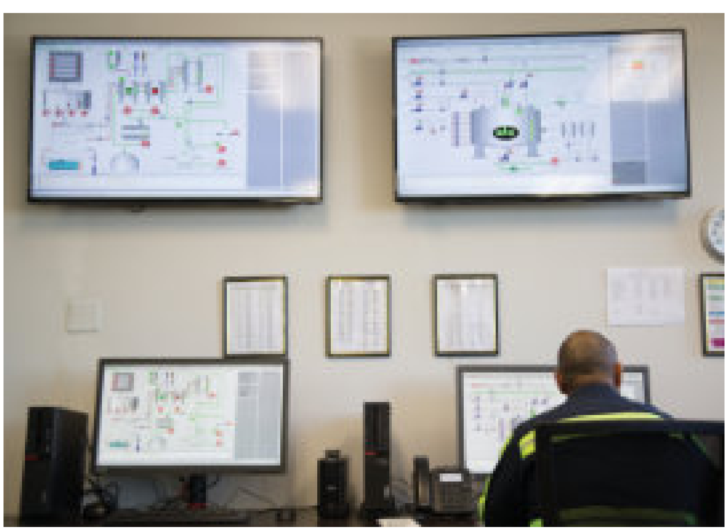
For thirty years, the District had been sending their biosolids to landfill, to be used as daily cover. This historical practice came with clear drawbacks; Class B biosolids that still contained pathogens, unpleasant odor, higher GHG emissions and the potential for "run-off" into local waterways.

The State of California is acutely aware of both the value and sensitivity of their natural environment and the inherent challenges associated with wasting valuable organic material in landfills. The State has been passing down ever-tightening regulations such as the banning of organics from landfills, the Healthy Soils Initiative and the Clean Water Act. All of these state-wide measures are designed to preserve the natural environment and improve resource management practices. With a desire to continue in its own, award-winning tradition of being proactive and with the certainty of stricter regulations on the horizon, the District understood that innovation was going to be required to invoke change. FSSD staff was also fortunate to have the support of a visionary board and local, political leadership. "We live in an area that is very sensitive to the environment and we're very much concerned about the Clean Water Act and the treatment of our "waste" products. Lystek allows us to be the utility of the future," says Harry Price, Mayor of Fairfield.



A FULLY-INTEGRATED SOLUTION

Management at FSSD also knew they wanted to work with an organization that shared their philosophy of taking a long-term view by looking beyond just the immediate challenges. They wanted a true partner. They found this with Lystek International. The company was able to demonstrate that they had developed a patented and proven, sustainable solution for biosolids and organics management. The multi-purpose, Lystek Thermal Hydrolysis Process (Lystek THP) was already successfully diverting hundreds of thousands of these potentially valuable materials from landfills and producing LysteGro®, a Class A EQ (Exceptional Quality) product that is high in organic matter and nutrients and that has been recognized by the California Department of Food and Agriculture as a licensed fertilizer. In addition to offering long-term pricing stability and a source of additional revenue for FSSD, the new Organic Material Recovery Center (OMRC) could also be retrofitted, to make better use of existing infrastructure and under-utilized assets. For example, it provides the District with enhanced operation of its digesters to increase biogas production for green energy and local growers with a nutrient-rich, organically-based biofertilizer product that is also affordable. "We're seeing more and more benefits of the project," shares Greg Baatrup, FSSD General Manager. The OMRC has the capability to recycle organics and produce alternative energy, thereby converting the traditional treatment plant into a Wastewater Resource Recovery Center (WRRC) and playing an important role in a more sustainable, circular economy.



"We gained a long-term solution, not only a management option, but a structure that makes pricing very certain over the next twenty years to help us manage our costs and deliver valuable services to our rate payers."

– Greg Baatrup, FSSD General Manager

SUCCESSFUL P3 PROJECT

After a decade of experimenting with a range of unreliable or incomplete solutions, this unique, Public-Private Partnership is already proving to be the perfect fit. Lystek's record of success and numerous operating facilities checked several boxes for FSSD. The ability to retrofit into under-utilized infrastructure, long term cost control and regulatory compliance, checked several more.

The twenty-year (+) partnership not only provides mutual peace of mind for FSSD and Lystek but, in fact, for all stakeholders, be it local or at the state level. "This is just (another) great example of what the power of creating partnerships is, partnerships between Suisun City and the City of Fairfield, the Sewer District, and Lystek. Let's talk about public-private partnerships. We all know how important these P3's are, because the government cannot do this stuff by itself. It never will be able to," states California State Assembly member, Bill Dodd.

COMPELLING EXAMPLE

At this point (2017), the partnership is in its early stages and already, the FSSD has a compelling story to share. The stakeholders are excited because the many benefits of the project are already clear. Everyone can see how, over the long term, they will go far beyond the simple conversion of biosolids into a Class A quality fertilizer product. This ground-breaking initiative is being viewed as a major step forward in reliable and sustainable, year-round organics management for the larger, Bay Area community and a successful model that supports the Healthy Soils Initiative, the Clean Water Act, and the evolving landscape of organics diversion in the state of California. It's about taking action and doing something tangible to eliminate needless "waste" – and it is a story others are eager to hear about and watch, including other agencies, associations and the State itself.

"This project is fast becoming the beach head for the United States (and a model) for the development of other, similar projects," says Baatrup.

About Lystek International

Lystek is a leading provider of Thermal Hydrolysis solutions for the sustainable management of biosolids and organics. The multi-use, award-winning Lystek system reduces costs, volumes and GHG's by converting municipal and industrial wastewater treatment facilities into resource recovery centers. This is achieved by transforming organic waste streams into value-added products and services, such as the patented LysteMize® process for optimizing digester performance, reducing volumes and increasing biogas production; LysteGro®, a high-value, nutrient-rich biofertilizer and LysteCarb®, an alternative source of carbon for BNR systems.

Nutrient Recovery & Reuse (NR2) Project

City of St. Cloud, Minnesota, USA

Lystek
Nothing wasted.
Everything to gain.

"The biggest, driving force behind the various upgrades to our biosolids program was that we were running out of storage," says Brian Shoenecker, Wastewater Services Manager for the City of St. Cloud

ABOUT

The City of St. Cloud is the 10th largest city in Minnesota. It is centrally located in the heart of the Midwest along the banks of the mighty Mississippi River. The City is the first municipality to use the Mississippi River as its drinking water source. Maintaining high water quality standards and preserving the integrity of the receiving waters are amongst the City's highest priorities.

CHALLENGES

- Biosolids storage capacity was under increasing pressure due to continued community growth, increased flows, and wet weather events shortening the land application season
- Anticipated future regulatory pressures to produce a Class A product for recycling to land
- Intention to increase co-digestion with additional organics, adding further pressure to residual volumes and storage
- Desire to retain and utilize as much existing treatment infrastructure as possible

SOLUTION

- Integration of the Lystek Thermal Hydrolysis Process (Lystek THP®) in a major (NR2 Project) plant upgrade

RESULTS

- A 70% decrease in biosolids volume significantly extending the capacity of the City's existing storage
- Production of a liquid, Class A quality biosolids product, which can be managed with the City's existing transportation and land application equipment
- $12 million in estimated cost savings over a 20 year life cycle as compared to alternative solutions

LOCATION & BACKGROUND

The St. Cloud Nutrient, Energy & Water (NEW) Recovery Facility is located in southern St. Cloud. The center services a population of about 120,000, including the City of St. Cloud and several area cities such as St. Augusta, St. Joseph, Sartell, Sauk Rapids, and Waite Park.

In 2014, the City began developing a Resource Recovery and Energy Efficiency (R2E2) Master Plan to remain well positioned to exceed future regulatory requirements and continue to be an innovative and sustainable utility. The primary goals of the R2E2 Master Plan were resiliency, cost-efficiency, innovation, excellence, and continuous improvement.

As a forward-looking utility, the St. Cloud NEW Recovery Facility had already been recognized as a leader in resource recovery. In fact, in 2017, the facility was one of only 25 water utilities in the United States to be named a "Utility of the Future Today", in recognition of its "leadership in community engagement, watershed stewardship, and recovery of resources such as water, energy, and nutrients", by the National Association of Clean Water Agencies (NACWA).

Armed with a notification in July 2017 from the Minnesota Public Facilities Authority that $6.6 million dollars in funds from a Point Source Implementation Grant had been made available to St. Cloud, the City embarked on an ambitious initiative, known as the Nutrient Recovery and Reuse (NR2) Project, to further advance their efforts in resource recovery. The grant was made possible by the Clean Water Legacy Act. Two of the primary goals of the NR2 initiative were to recover phosphorous and produce a fertilizer product at its facility.

PROJECT DRIVERS

Prior to the implementation of the Lystek THP solution, the City had already established a highly successful, Class B, liquid biosolids management program. However, as the surrounding community continued to grow and the facility continued to accept increasing organics for co-digestion, it became obvious there would be increasing pressure on the existing storage capacity at the center. This was a challenge that needed to be addressed. Simply put, City staff understood that, in the near future, they would run out of capacity to store their liquid (3-4% solids) material. Therefore, they needed to implement a plan that would reduce the volume of their low solids content product.

In addition, St. Cloud wanted to achieve a Class A quality product to prepare for possible changes in future regulatory requirements. With the Lystek THP system, St. Cloud was able to fnd a solution to address both of these key project challenges/drivers, while continuing to utilize and maximize the value of their existing infrastructure.

"We were trying to find a way – a process or a technology – where we could continue to provide a liquid fertilizer product to our agricultural customers. That's what they like, that's what they ask for, so we evaluated a number of alternatives to find a solution that would be a good fit."

– Tracy Hodel, Assistant Public Utilities Director for the City of St. Cloud.

LYSTEK THP SELECTED

The solution also had to align with the St. Cloud's commitment to innovation in nutrient reuse and recovery and be as cost effective as possible for its ratepayers.

Evaluation included several options, such as producing a dewatered cake.

According to Hodel, "We were in our facility planning phase when we frst heard about Lystek. The timing was perfect. We were looking at various solutions and we are known for being innovative and taking some (measured) risk in our approach, including different technologies. It started with a conference call and evolved into a detailed review of the Lystek THP system. What really impressed us was how well it ft with our existing infrastructure and equipment. Plus it enabled us to continue providing the type of end product our agricultural customers prefer and ask for."

Bench scale testing was initiated in 2015 to evaluate the effect of the Lystek THP approach on St. Cloud's biosolids. The process features a patented and proven combination of low temperature heat (167^{o} F/75^{o}C) via low-pressure steam, alkali addition (to pH 9.5), and high-speed shearing to achieve a variety of benefts for wastewater treatment facilities. Results of this initial testing showed that St. Cloud's residuals could be dewatered and processed through the Lystek THP system, achieving a Class A quality, liquid biofertilizer product (LysteGro®) that is also high in essential nutrients and vital organic matter.

Ultimately, Lystek was selected by the city of St. Cloud. Project construction began in 2017 and the Lystek THP system was successfully commissioned and being independently operated by City staff by September, 2018.

COST SAVINGS

Utilizing existing infrastructure also contributed signif cantly to overall cost savings for St. Cloud.

"Not only did it meet our sustainability goals and our customer's needs in terms of the liquid product, but it also saved us on capital money because we didn't have to build a new cake storage building. We didn't have to change our injection or our recycling equipment. So, as far as the total project goes, we are projecting approximately $12 million in lifecycle savings over 20 years." **– says Tracy Hodel**

The ability for the City to advance their successful land application program, while reducing and controlling costs, were key selling features of the project.

In addition to the bene f ts of the City being able to continue using their existing liquid land application trucks and equipment, they were also able to utilize existing plant infrastructure, such as liquid storage tanks, buildings, and the truck loading station. The concentrated nature of the LysteGro product dramatically extended the capacity of St. Cloud's existing storage, thus solving this challenge. Further, the high solid, liquid properties of the product maintained pumping, loading, and unloading ef f ciencies, while also dramatically decreasing the amount of road time and wear and tear on trucks, overtime, and the number of passes the application equipment must undertake, per f eld.

"The cost savings alone on this project are significant with reduced maintenance on equipment, staff overtime and so forth. Not to mention the advantages of being able to move the product from storage to the fields and into the ground when it's timely for our agricultural customers."

– Brian Shoenecker

SUMMARY OF SUCCESSES

Overall, implementation of the Lystek solution as part of St. Cloud's vision and leadership in innovation and sustainability in biosolids management was an efficient, affordable, and seamless transition.

The system was deployed within the City's existing infrastructure and has reduced the volume of material going to storage by 70%, thereby significantly extending operational capacity to accommodate future growth. Since inception of this program, St. Cloud has also successfully increased the amount of food and beverage byproducts they have been co-digesting from 5,000 to over 20,000 gallons per day with no process disruptions. This has enabled the City to enhance their comprehensive resource recovery program and service offering to the region.

Plus, St. Cloud's land application program was able to proceed without interruption, and they are now producing a Class A biosolids product that their customers want and need.

Additionally, in terms of forward planning, because the Lystek THP system is modular and flexible, it can be further leveraged in the future to integrate with other components of the plant and provide further value, such as the LysteMize® approach to digester optimization for increased biogas production. Or, should the City ever require additional carbon for its BNR system, this could be achieved through the provision of LysteCarb®. On-site research has also shown the ability for the Ostara WASSTRIP® process (also implemented as part of the NR2 project), to utilize this material as a carbon source for additional nutrient removal at the plant.

One System. Multiple Benefits.

Patrick Shea, Director of Public Utilities for the City, sums up the project this way; "One of the aspects that makes me smile when I reflect on the NR2 Project as a whole is the culture of wastewater treatment going from sewage to sewer plant to wastewater treatment facility and now to full-blown resource recovery. This is an industry game changer. We're reusing the organic material, we're reusing the nutrients, and we're converting these materials back into useful products that can help rebuild our soils while benefiting the environment over the long-term."

About Lystek International

Lystek is a leading provider of low temperature Thermal Hydrolysis solutions for the sustainable management of biosolids and organics. The multi-use, award-winning Lystek system reduces costs, volumes and GHG's by converting wastewater treatment facilities into resource recovery centers. This is achieved by transforming organic waste streams into value-added products and services, such as the patented LysteMize® process for optimizing digester performance, reducing volumes and increasing biogas production; LysteGro®, a high-value, nutrient-rich biofertilizer and LysteCarb®, an alternative source of carbon for BNR systems. **www.lystek.com**

APPENDIX C

Examples of Awards and Honors

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Examples of Awards and Honors

2018	California Association of Sanitation Agencies ***Excellence in Innovation & Sustainability*** Fairfield Organic Materials Recovery Center & Fairfield-Suisun Sewer District
2018	Canadian Construction Association ***Sustainable Management of Biosolids & Organics*** International Business Award
2017	California Environmental Protection Agency ***Governor's Environmental & Economic Leadership Award*** Fairfield Organic Material Recovery Center
2017	Water Canada/Water's Next ***Wastewater Technology*** National Award
2017	Water Canada/Water's Next ***Company of the Year*** National Award
2015	Canadian Association of Municipal Administrators ***CAMA Environmental – Biosolids Management*** City of North Battleford, Saskatchewan
2013	Water Environment Association of Ontario ***Exemplary Biosolids Management – Technology Development*** Southgate Organic Material Recovery Center
2008	Water Environment Association of Ontario ***Exemplary Biosolids Management - Integrated BNR System*** St Marys Ontario
2005	National Research Council of Canada ***Sustainable Development*** Ontario Region

**Click on each award title to link to the full award details.*

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APPENDIX D

Our Team's Experience and Expertise

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Our Team's Experience and Expertise

Michael Beswick, M.A.Sc., P.Eng. – Executive Vice President

Mr. Beswick is a Professional Engineer whose career has focused on the development of environmental engineering technologies in the wastewater, water, and waste management sectors. Over the last decade, he has been instrumental in designing and managing both in-plant deployments and Lystek owned merchant facilities. Mr. Beswick has an established record in the successful and timely completion of projects in accordance with applicable regulations. He also plays a pivotal role in the optimization of the Lystek process and solution offerings. Mr. Beswick will bring his expertise to the team as Project Director, overseeing project development and execution.

Ajay Singh, Ph.D. – Co-Founder & Technical Director

Dr. Singh has over 25 years of international experience in managing industrial operations and research and development with a background in applied & environmental microbiology, and bioprocessing technology. He is one of the original founders of Lystek. Dr. Singh has developed numerous bioreactor-based processes related to water/wastewater environment, biotechnology, and fermentation & food industries. Dr. Singh is our internal regulatory expert, who liaises with US EPA and Canadian regulators on a regular basis related to Lystek technologies and products.

James Dunbar, P.E., M.BA. – General Manager Fairfield OMRC/Business Development Manager, Western US

Mr. Dunbar is a Professional Engineer (in six U.S. states) with over 25 years experience in the management of solid waste and treatment of liquid wastes in the U.S. and Europe. Jim has worked within the regulatory levels at the federal, state and local levels dealing with permitting and environmental compliance. Jim is an active member in the California Association of Sanitation Agencies (CASA) and the Northwest Biosolids Management Association. Mr. Dunbar will serve as Project Manager. Responsibilities include conducting monthly progress meetings, scheduling internal tasks, and providing client liaison.

Alex West, M.A.Sc., P.Eng. – Senior Engineer, Project Manager

Alex is a Professional Engineer with over 10 years of process engineering experience in the industrial wastewater treatment and oil and gas sectors. He has experience throughout the life cycle of a project, from full-scale industrial installations to mobile pilot applications. Additionally, he also has extensive technology development experience. In his role at Lystek, he is a senior engineer and project manager and has led or collaborated on various projects such as recent installations in Goleta, California and Innisfil, Ontario.

Raj Nandakumar, B.Sc., P.Eng. – Senior Engineer

Mr. Nandakumar is a Professional Engineer with over 17 years of technical and management experience across environmental consulting, manufacturing, and automation fields. He has designed, lead, and implemented environmental solutions at the single facility, national, and global level. In his role at Lystek, Mr. Nandakumar is responsible for significant capital and new technology deployments. This has included the design and project management of Lystek's largest and most advanced Organic Material Recovery Center (OMRC) in Fairfield, California and our recent installation in St. Cloud, Minnesota.

Samantha Halloran, M.Sc., P.Ag. – Product Manager

Ms. Halloran is a Professional Agrologist, with a background in agriculture and environmental compliance. Her master's research assessed nutrient availability, and examined the fate of emerging contaminants in alkaline stabilized biosolids. Samantha has a passion for environmental stewardship, with a specific interest in nutrient recycling and soil health. She oversees product management at Lystek, which includes new product and new market development, fertilizer registrations, land application and agricultural research projects.

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APPENDIX E

Lystek THP Product and Service Offering

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Lystek

Nothing wasted.
Everything to gain.

One System
Multiple Benefits
for Biosolids & Organics Management

Lystek THP® is an innovative and award-winning resource recovery solution with multiple benefits for biosolids and organics management.

Lystek's unique, physical-chemical thermal hydrolysis process uses a combination of high speed shearing, alkali, and low pressure steam in an enclosed Reactor to transform digested or undigested biosolids and/or organics into a multi-purpose hydrolyzed product.

The process disintegrates microbial cell walls and hydrolyzes complex macromolecules into simpler and readily biodegradable compounds. This provides operational flexibility, with multiple uses for process optimization and resource recovery:

- **LysteGro®** Class A Biosolids Fertilizer
- **LysteMize®** Anaerobic Digester Optimization
- **LysteCarb®** Alternative Carbon Source

This process transforms dewatered feedstocks, ideally in the range of 16 - 18% total solids, into a high-solids (13-16%) liquid product with a viscosity below 10,000 centipoise. This product is fully pumpable using traditional liquid processing, handling, and application equipment.

The system has a small footprint and is simple to operate, modular, and flexible. Lystek THP can be easily integrated into existing WWTPs typically at the end of the solids process train, with little to no disruption to other WWTP processes.

This process can be deployed as an on-site or off-site solution (regional facility) and is scaleable to service small, medium, and large residual generators.

Due to the user friendly and easy to operate nature of Lystek THP, typically no additional operators are needed beyond existing staff and no specialized operator certifications are required.

BENEFITS:

- Recovers valuable nutrients & organics
- Energy efficient process
- Easy to operate and maintain, with no additional operators required
- Small processing footprint with ability to retrofit into existing infrastructure
- Comprehensive product management services
- Processes digested or undigested residuals
- Mitigates odors with an enclosed system
- Integrates easily with multiple resource recovery technologies

"Use of this proven technology and development of this project is playing an important role in capping operational expenses related to biosolids management. It also allows us to diversify our resource recovery options by leveraging existing, under-utilized infrastructure to generate additional revenues, further offsetting costs"

Greg Batruup, General Manager,
Fairfield-Suisun Sewer District

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One System. Multiple Uses.

Lystek THP provides operational fexibility. By installing one THP Module, utilities can produce Class A quality biosolids fertilizer (**LysteGro**) and have the fexibility to recirculate the hydrolyzed material to enhance anaerobic digester performance (**LysteMize**) or be used as a supplemental carbon source for BNR (**LysteCarb**). This technology optimizes full-cycle resource recovery.

LysteCarb
Alternative Carbon

Carbon is required to facilitate the removal of both Nitrogen (N) and Phosphorous (P) in biological nutrient removal (BNR) systems. When WWTPs do not have suffcient organic carbon in their incoming wastewater, a consistent, supplemental source of carbon is used to ensure reliable performance.

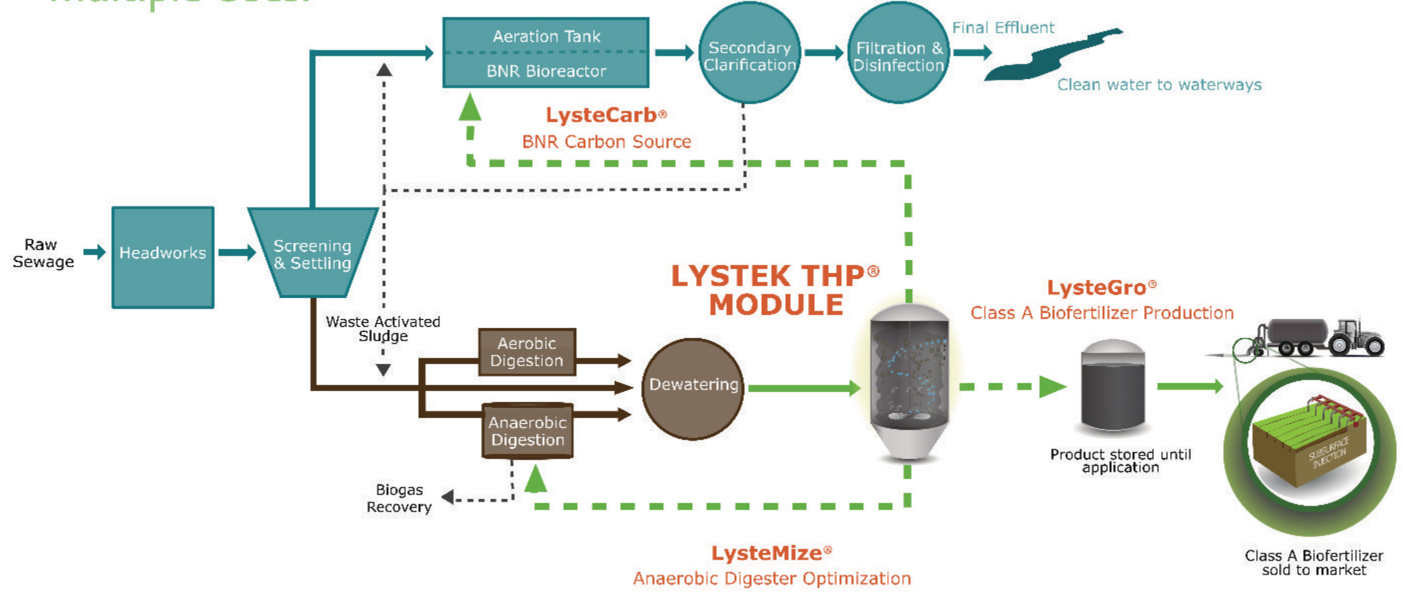
Lystek hydrolyzed biosolids can be used as a safe, cost-effective alternative carbon source. We call this product **LysteCarb®**. Not only does LysteCarb contain a much higher COD:N:P ratio than raw wastewater, but the material is also much higher in concentrations of readily biodegradable COD (SCOD). This product can thereby replace costly conventional chemicals such as methanol, glycerol, or acetic acid.

When recycled in BNR systems, LysteCarb provides readily available carbon for denitrifcation and Enhanced Biological Phosphorus Removal (EBPR).

Simply put, LysteCarb offers enhanced BNR system operations with a safer, cost effective source of carbon for enhanced biological denitrifcation and phosphorous removal. This process also reduces residual volumes requiring management.

LysteCarb and LysteMize Characteristics	
Soluble Chemical Oxygen Demand (SCOD)	40-50%
Total Chemical Oxygen Demand (TCOD)	105,000 - 150,000 mg/L
Volatile Fatty Acids (VFA)	10,000 - 15,000 mg/L

One System.
Multiple Uses.



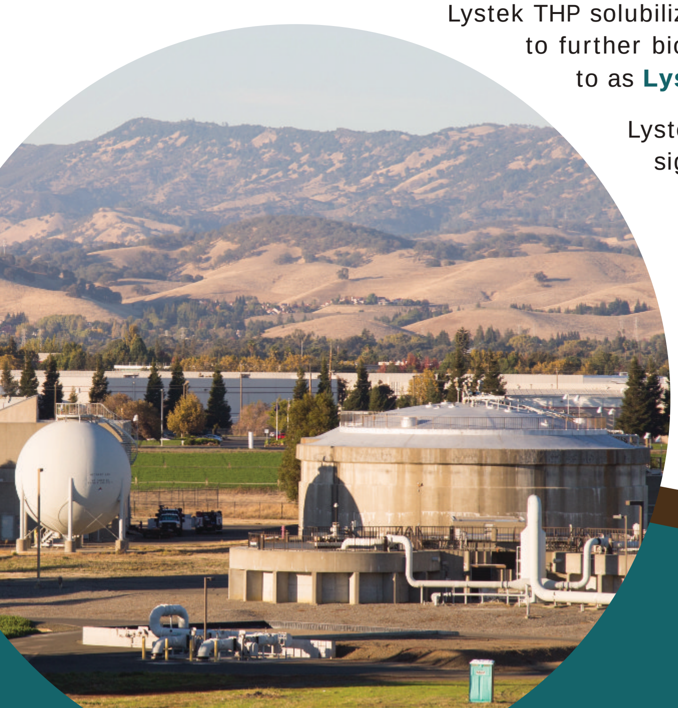
LysteMize
Digester Optimization

Lystek THP solubilizes organic compounds, making the digested residuals more amenable to further biodegradation when re-fed to anaerobic digesters (AD). This is referred to as **LysteMize®**.

Lystek's hydrolyzed product contains 40-50% of the TCOD as SCOD, and signifcantly increased VFAs versus typical biosolids.

The addition of this substrate to the digester allows for quicker conversion to biogas. This not only improves the biodegradability of organic compounds in the hydrolyzed product that were not digested in the frst pass through, but also enhances overall digester kinetics.

LysteMize enhances biodegradation of volatile solids by up to 20% and can increase biogas yields by up to 40%. This optimizes resource recovery and further minimizes residuals requiring management offsite.



LysteGro
Biofertilizer

Lystek THP's cornerstone product is a pathogen free, high-solids liquid biofertilizer product, called **LysteGro®**. LysteGro meets the US Environmental Protection Agency's (EPA) criteria for a Class A biosolids and the Canadian Food Inspection Agency's (CFIA) criteria for a registered fertilizer.

Growers value LysteGro because of the predictable NPK values, organic matter, soil incorporation and, most importantly, the fertilizer's performance.

Third-party studies have shown LysteGro can completely replace commercial fertilizers and result in superior crop yields.

LysteGro is injected into the soil subsurface during application to maximize nutrient use effciency and mitigate odor and run-off potential. The in-feld aesthetics and cleanliness of the injection operation that we employ are superior to surface application methods.

Our technology and product management services are proven to maximize value for both the end-user and generator. We have sold over one million tons of LysteGro, with market price continuing to rise. This rising fertilizer value can be used to offset utility's biosolids program costs.

Community Fertilizer Programs

- ***Long-term sustainable program***
- ***Produce a valuable fertilizer***
- ***Good value to local farmers***
- ***Opportunity to offset program costs***
- ***Closing the loop between generators and local agriculture***

Advantages of a High-Solids Liquid Biofertilizer

- Simple, cost effective liquid pumping and storage systems
- Transportation loading and unloading effciencies
- Odor mitigation with enclosed system
- Effcient and cost effective land application
- Maximizes carbon and nutrient value
- Mitigates risk of runoff and enhances environmental protection
- Improves in-feld aesthetics with subsurface injection
- Quality fertilizer improves yields and reduces input costs

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ABOUT LYSTEK INTERNATIONAL

Lystek was founded in 2000 at the University of Waterloo, in Ontario Canada and is owned by the Tomlinson Group. We are a multi-award-winning organics processing and management company, with locations across North America.

Lystek has proven this technology and service offering across a range of small, medium, and large communities in North America. We work with public and private sector clients to enhance operations and recover valuable nutrients from biosolids and other organic feedstocks.

We work with our customers as long-term partners. Owning and operating our own facilities allows us to conduct ongoing commercial-scale research and development. In doing so, we continuously optimize our technology and processes to realize operational improvements. As part of our commitments to our customers, we share these enhancements to maximize their investment in the Lystek solution.

"It was unreal, how easy the deployment of this system was. This, combined with the small footprint, low cost and excellent support from the Lystek team - it was almost like the system was designed especially for our facility."

Stewart Schafer, Director of Utility Services, City of North Battleford

WHAT WE OFFER

Design–Build–Transfer, Technology & Equipment Supply

We have extensive experience working with generators and consulting engineers to design and build a solution that is ideal for each facility.

We have deployed our technology as new builds as well as retroftted our Modules into existing infrastructure.

We are equipped to provide complete design-build-transfer services for generators looking to implement Lystek THP. We are also comfortable supplying our technology as part of a broader team.

Regional Solutions

We own and operate large regional Organic Material Recovery Centres (OMRCs) in Fairfeld, California and the Township of Southgate, Ontario.

The OMRCs receive digested & undigested material (1-35% TS) from generators in the region. These facilities produce Class A quality biosolids fertilizer that is sold to the local agricultural market for benefcial use.

Contact us for more information about having your residuals processed at these facilities.

Comprehensive Product Management

We offer comprehensive product management services assuming full responsibility for the LysteGro fertilizer program for our in-plant installations.

Utilities can take comfort in knowing their biosolids are handled according to industry best management practices.

The combination of our cost-effective technology and product management service provides a turnkey solution our customers are satisfed with.

This full service approach sets us apart from technology vendors.

CONTACT US: T. 226.444.0186 | TF. 888.501.6508
E. info@lystek.com | www.lystek.com

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APPENDIX F

Why Choose Lystek THP

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Why Choose Lystek THP®

Comparing Lystek THP to Alternative Class A Treatment Technologies

	Heat Dried Pelletized Product	Alkaline Stabilized Dry Product	Compost	High Pressure THP	Lystek THP®
Operating Benefits					
No additional operators required	✗	✗	✗	✗	✓
Does not disrupt upstream processes	✓	✓	✓	✗	✓
Small processing footprint	✗	✗	✗	✗	✓
Rapid processing time	✗	✗	✗	✓	✓
Fully enclosed system, minimal process air	✗	✗	✗	✓	✓
No potential for dust generation	✗	✗	✗	✓	✓
Digester enhancement	✗	✗	✗	✓	✓
Multiuse carbon source for nutrient removal	✗	✗	✗	✗	✓
Fertilizer Product Benefits					
Market ready fertilizer	✓	✓	✓	✓	✓
High solids liquid advantage	✗	✗	✗	✗	✓
Sub-surface injected	✗	✗	✗	✗	✓
Full NPK nutrient value	✗	✓	✗	✗	✓
Suitable for precision agriculture	✓	✗	✗	✗	✓
Economic Benefits					
Low capital cost	✗	✗	✓	✗	✓
Fertilizer revenue sharing options	✗	✗	✗	✗	✓
Reduced dewatering polymer consumption	✗	✗	✗	✗	✓
Environmental Benefits					
Contributing to the circular economy	✓	✓	✓	✓	✓
Reduced energy inputs	✗	✗	✓	✗	✓

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APPENDIX G

Technical Specifications Sheet

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Lystek
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Lystek THP® Technical Specifications

About the Technology

The Lystek low temperature Thermal Hydrolysis Process (Lystek THP®) is an innovative, award-winning, proven biosolids and organics management solution.

Lystek THP transforms raw or digested organic feedstocks into a Class A quality biosolids fertilizer and multi-use hydrolyzed product. This technology ofers one system with multiple benefts. This system enables wastewater treatment plants to enhance biogas production while reducing residual volumes, costs, odors, and greenhouse gases (GHGs).

Operating inputs are low pressure steam, high speed shearing, and alkali, all applied simultaneously in an enclosed Reactor.

One System. Multiple Benefits:

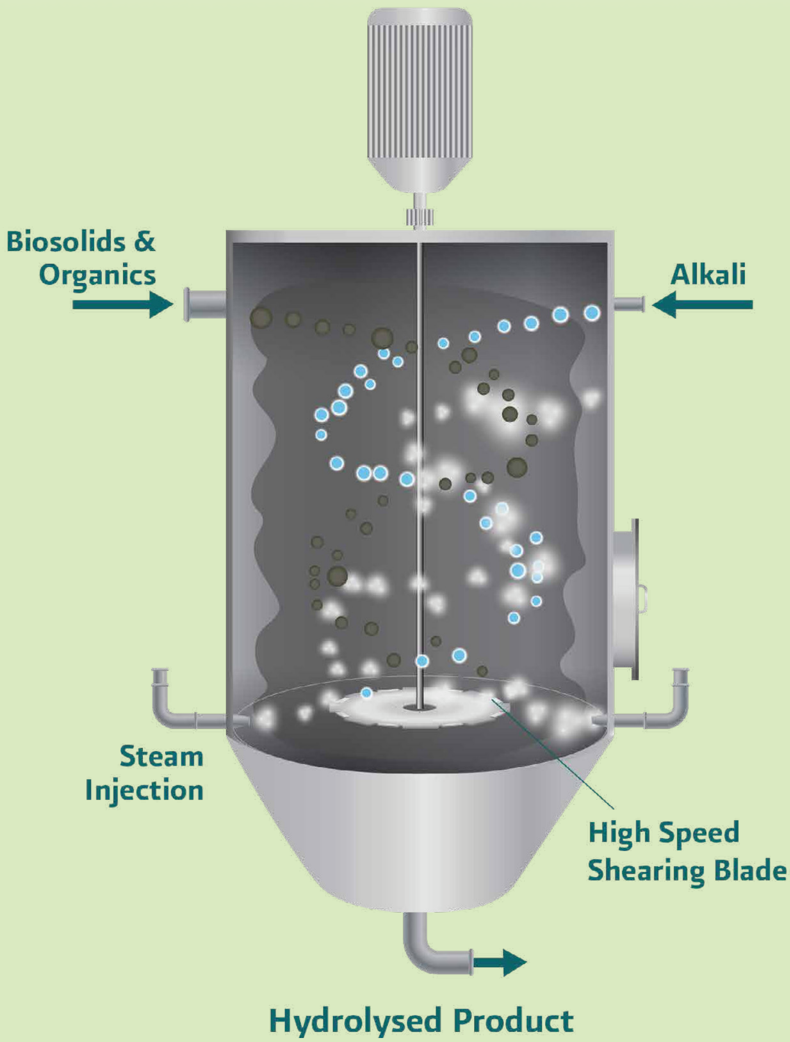
Lystek THP has a small footprint, is cost effective, fast, effcient, reliable, and proven.

Modular design makes it scalable and easy to deploy (or retroft). The system is fully automated and simple to operate and maintain.

Additional advantages of the solution include:

- Creates a marketable, high-solids liquid Class A biosolids
- Comprehensive product management services
- Optimizes anaerobic digesters; increasing biogas production for green energy while decreasing residual volumes through improved volatile solids reduction (VSR)
- Produces a safe, cost-effective alternative source of carbon for biological nutrient removal (BNR) systems
- Processes digested (anaerobic or aerobic), WAS, or raw residuals
- Augment to existing plants - does not disrupt process fow
- Operational simplicity - no additional operators required
- Efective odor mitigation with an enclosed system
- Ease of integration with multiple resource recovery technologies

Lystek THP® Reactor



LysteGro® - Class A biofertilizer

LysteMize® - Anaerobic digester optimization

LysteCarb® - Alternative carbon source

Module[i] Sizing

Module size	LY3	LY6	LY10
Processing rate (dry tons per hour)	0.3	0.6	1.0
Typical processing footprint[ii] (ft^2)	800	1,250	1,600

Key Operating Parameters[iii]

Electrical consumption	60 kw-h per dry ton
Heat requirement[iv]	1,100,000 BTU per dry ton
45 % liquid alkali solution[v]	190 - 230 lb per dry ton
Operating temperature	167°F / 75°C
Solids content - processed product	13 - 16%
Viscosity - processed product	5,000 – 10,000 cP

End Product Value/Options

LysteGro® biofertilizer	Meets/exceeds Class A biosolids criteria
LysteMize® digester optimization	Increase biogas production by up to 40% and volatile solids reduction by up to 25%
LysteCarb® alternative carbon source	Eliminate use of costly chemicals (i.e. methanol, glycerol) used for BNR

[i] Module includes the THP Reactor, associated pumps and hopper.

[ii] Minimum space required for processing equipment only (Module, alkali storage, boiler) only. Product storage and air treatment system requirements will vary by site conditions.

[iii] Operating parameters are estimates only and will vary according to site conditions, feed stock characteristics, and intended use of hydrolysed product.

[iv] Dependent upon biosolids feed temperature into the Reactor. Heat requirements estimated based upon an average feed temperature of 60°F.

[v] Typically recommend potassium hydroxide (KOH). For larger facilities, lower cost alkali sources can be considered.

+ Modular and scalable to any population size.

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lystek.com

APPENDIX H

Conceptual Drawings

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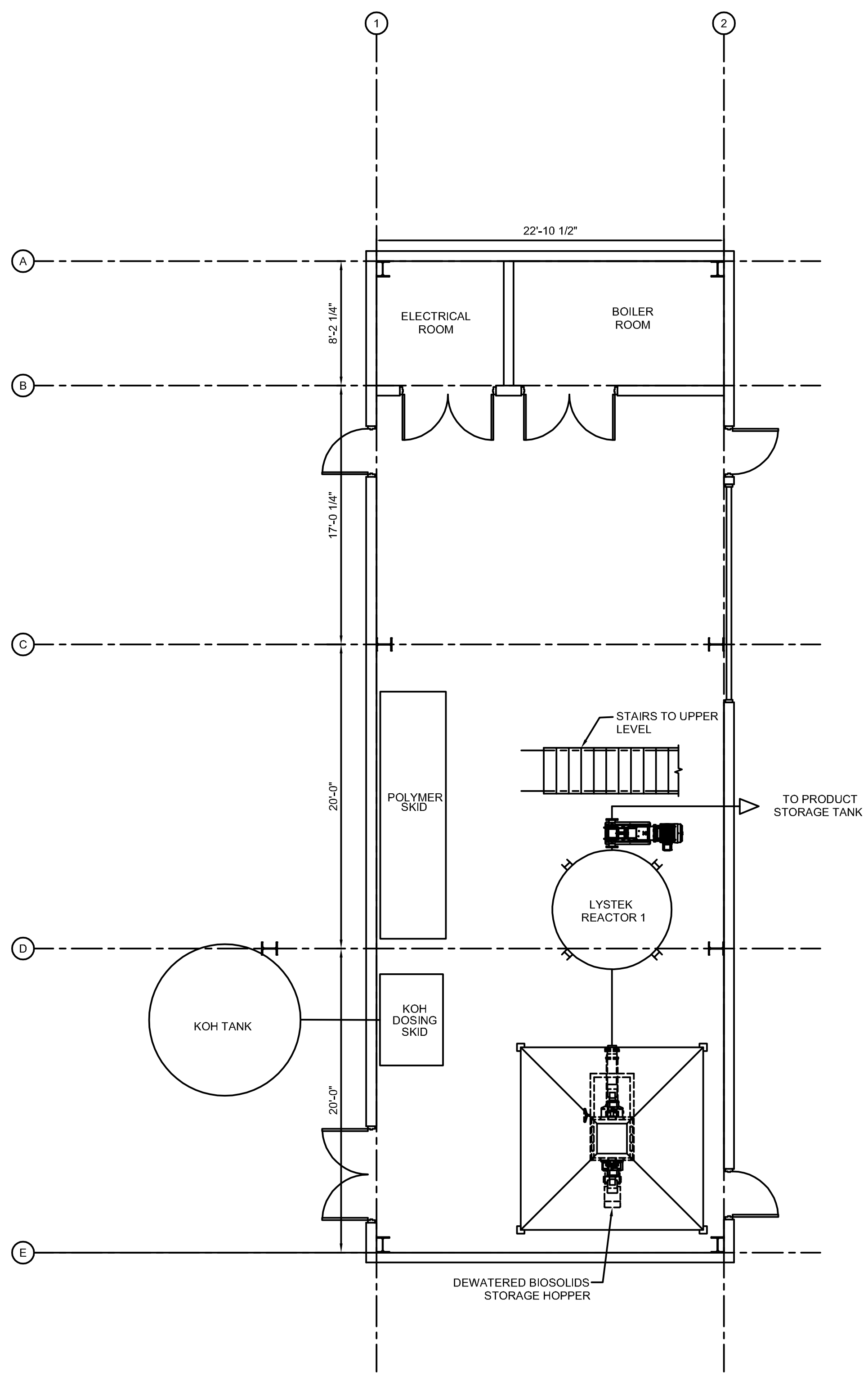


N

CONCEPTUAL

Automated Engineering Technologies Ltd.
91A Duke Street , Guelph, Ontario N1E 5L1 (519)821-8644
397 Romeo Street S., Stratford, ON, N5A 4V1 (519)273-9318 WEB: www.autoengtech.on.ca

No.	REVISION	DATE

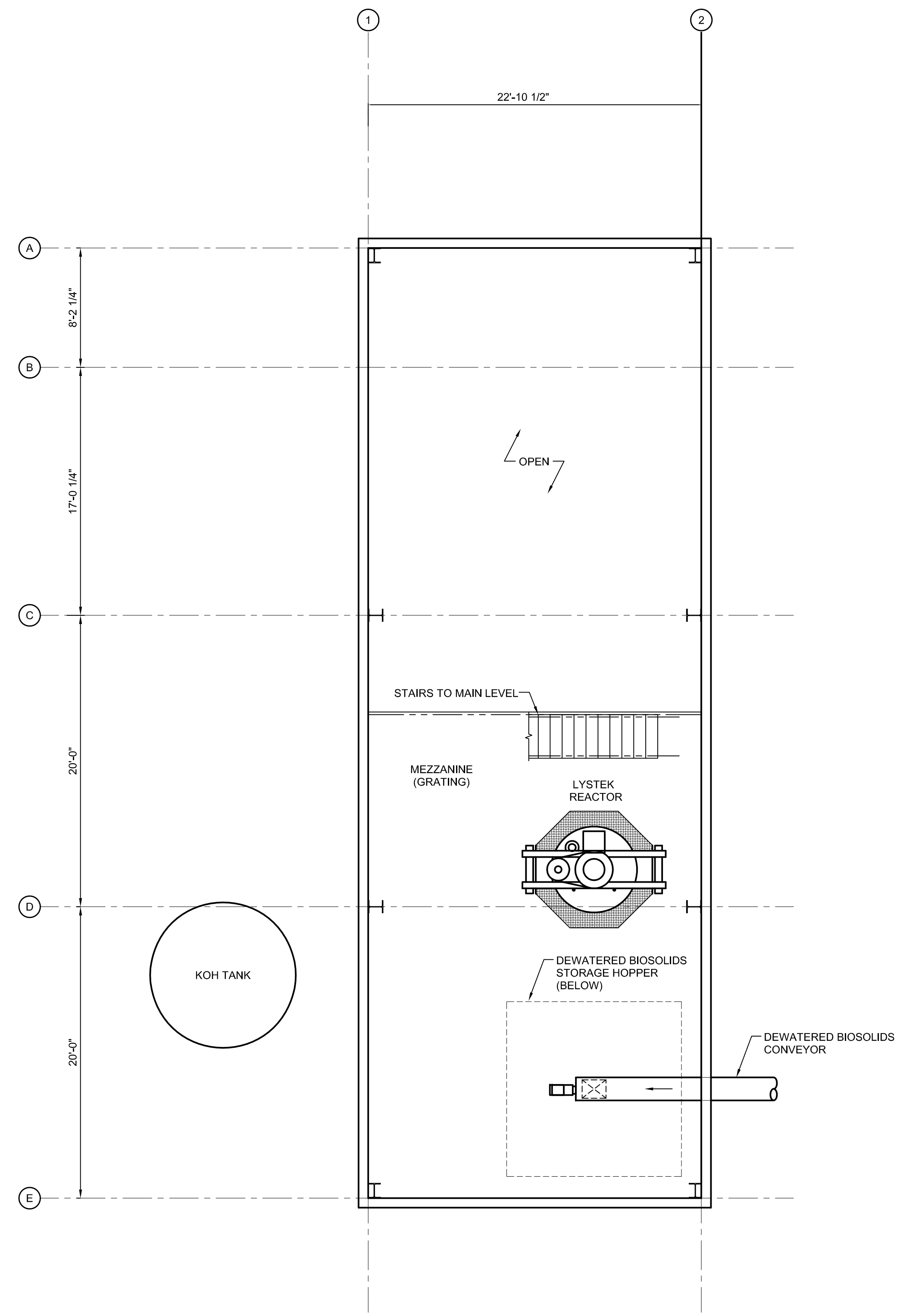
APPROVED BY:

LYSTEK OMRC FACILITY

PROPOSED FACILITY LAYOUT
MAIN FLOOR PLAN

Lystek International Inc.
125 McGovern Drive, Unit #1
Cambridge, Ont., Can., N3H 4R7
Phone: 1-888-501-6508
Fax: 1-888-501-7429
Web: www.lystek.com

DESIGNED BY:	REVIEWED BY:	DRAWN BY:	DATE:
M.B.	R.M.	P.R.V.	NOV. 2018
SCALE:	PROJECT No.	DRAWING No.	
-	-	A101	



CONCEPTUAL

Automated Engineering Technologies Ltd.
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397 Romeo Street S., Stratford, ON, N5A 4V1 (519)273-9318 WEB: www.autoengtech.on.ca

No.	REVISION	DATE

APPROVED BY:

LYSTEK OMRC FACILITY

PROPOSED FACILITY LAYOUT
UPPER LEVEL PLAN

Lystek International Inc.
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Cambridge, Ont., Can., N3H 4R7
Phone: 1-888-501-6508
Fax: 1-888-501-7429
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DESIGNED BY:	REVIEWED BY:	DRAWN BY:	DATE:
M.B.	R.M.	P.R.V.	NOV. 2018
SCALE:	PROJECT No.	DRAWING No.	
-	-	A102	

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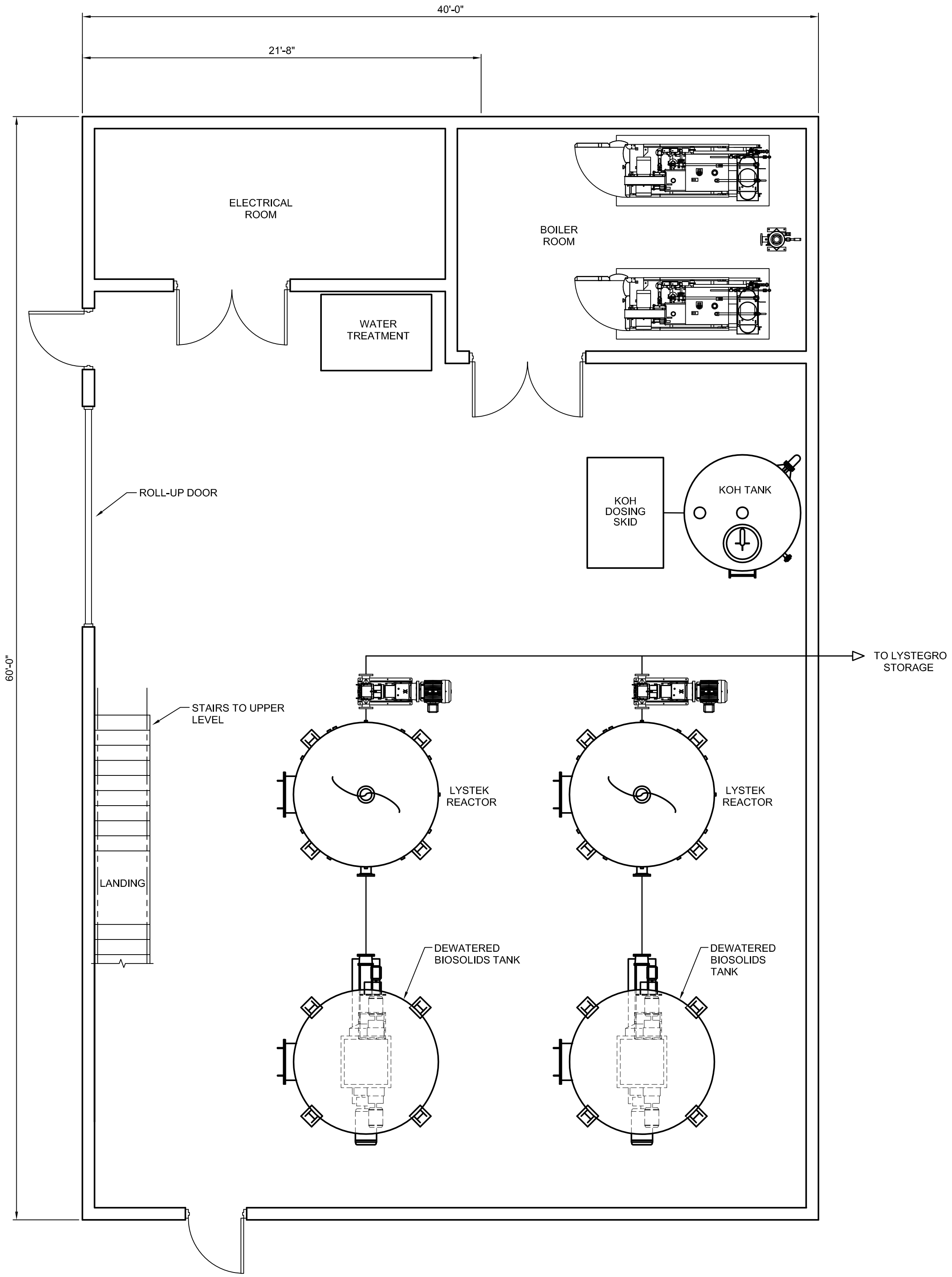
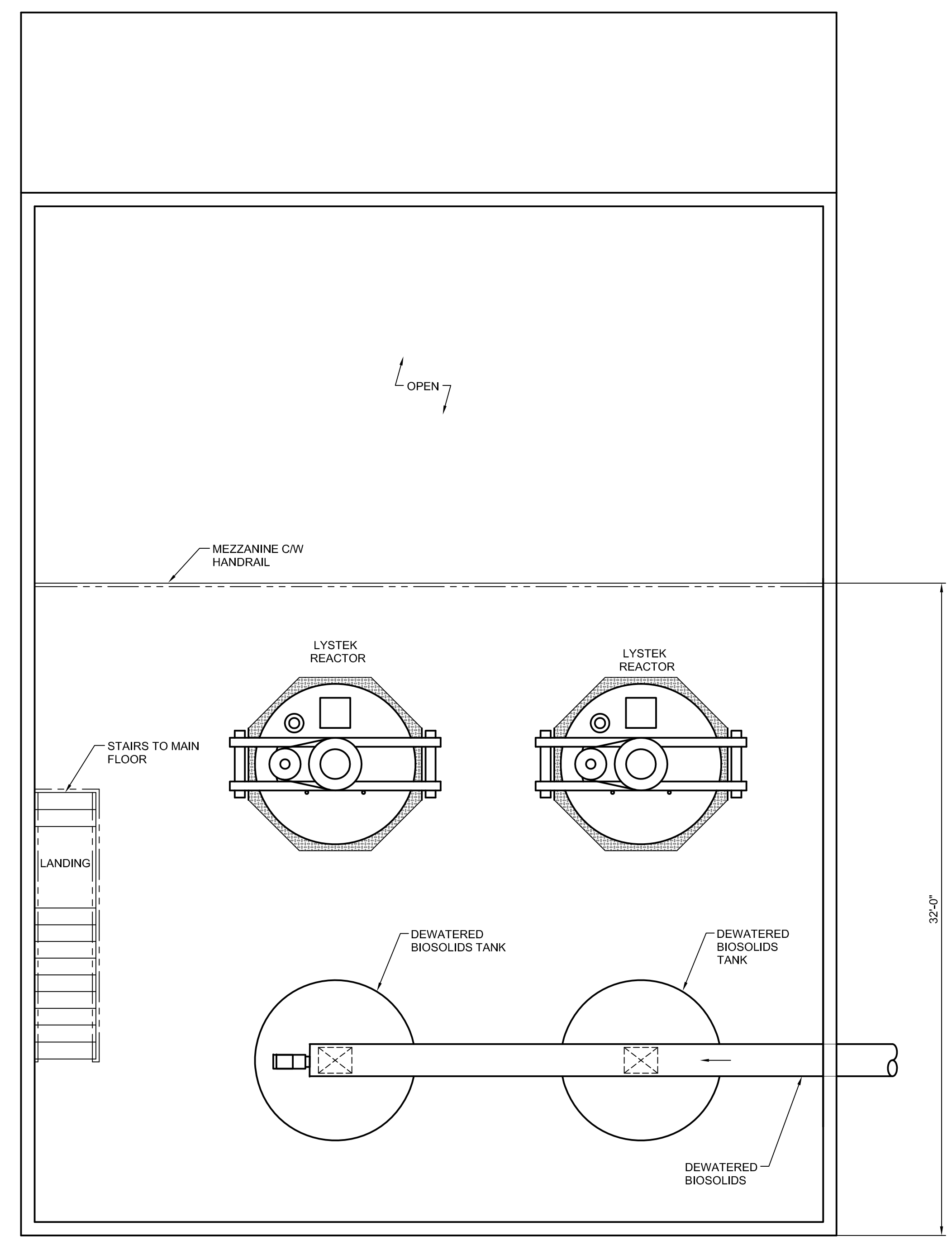


MAIN FLOOR PLAN



MEZZANINE LEVEL PLAN

SCALE BAR 0 5' 10' 15'

CONCEPTUAL

Automated Engineering Technologies Ltd.
91A Duke Street, Guelph, Ontario N1E 5L1 (519)821-8644
397 Romeo Street S., Stratford, ON, N5A 4V1 (519)273-9318 WEB: www.autoengtech.on.ca

No.	REVISION	DATE

APPROVED BY:

LYSTEK THP SYSTEM

CONCEPTUAL FACILITY LAYOUT

MAIN FLOOR AND MEZZANINE PLANS

Lystek International Inc.
125 McGovern Drive, Unit #1
Cambridge, Ont., Can., N3H 4R7
Phone: 1-888-501-6508
Fax: 1-888-501-7429
Web: www.lystek.com

Lystek www.lystek.com

DESIGNED BY:	REVIEWED BY:	DRAWN BY:	DATE:
M.B.		P.R.V.	FEB 2019
SCALE: AS SHOWN	PROJECT No. -	DRAWING No. A101	

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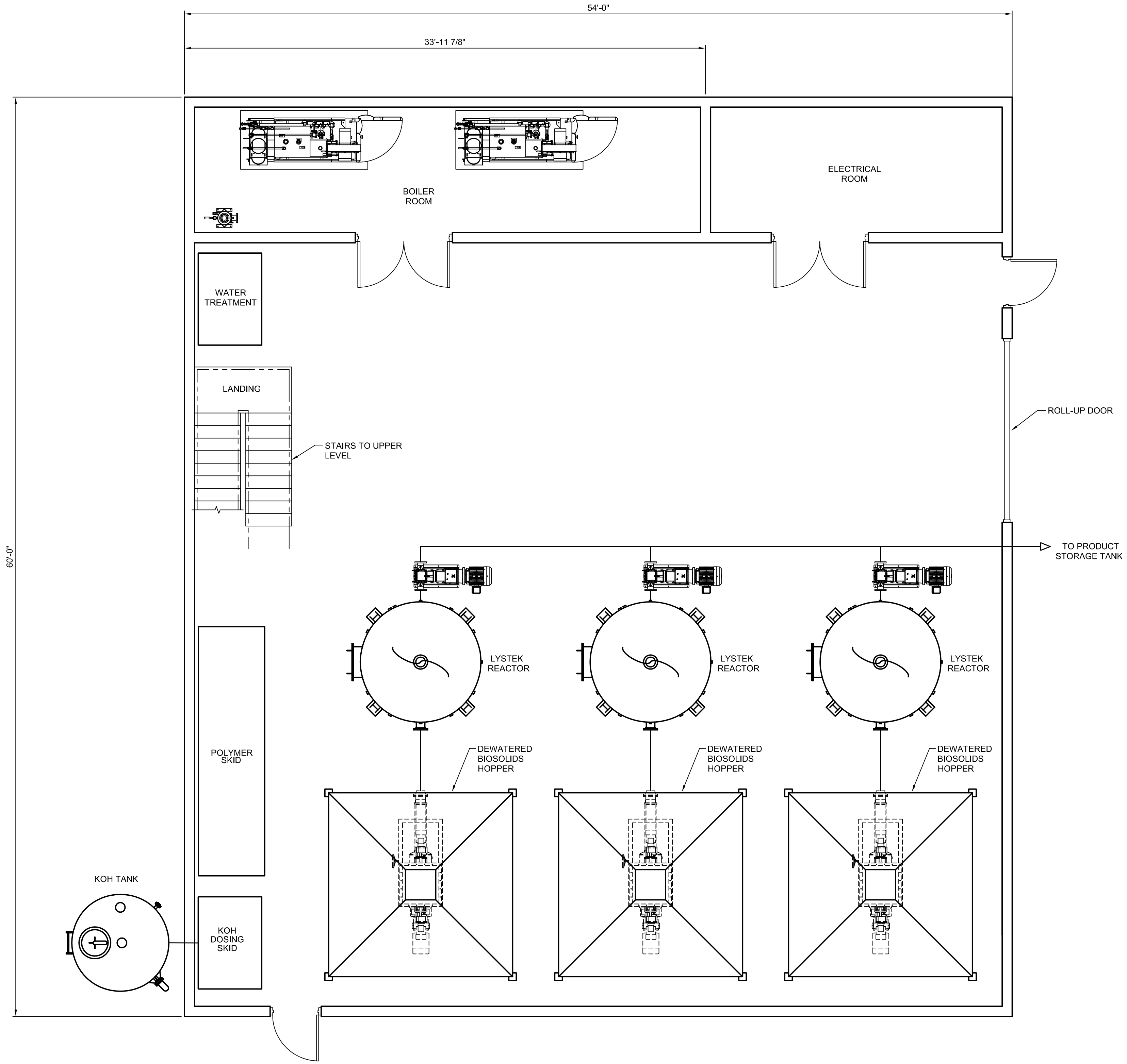

MAIN FLOOR PLAN

SCALE BAR
0 5' 10' 15'

CONCEPTUAL

Automated Engineering Technologies Ltd.
91A Duke Street , Guelph, Ontario N1E 5L1 (519)821-8644
397 Romeo Street S., Stratford, ON, N5A 4V1 (519)273-9318 WEB: www.autoengtech.on.ca

No.	REVISION	DATE

APPROVED BY:

LYSTEK OMRC FACILITY

PROPOSED FACILITY LAYOUT
LY10 x 3
MAIN FLOOR PLAN

Lystek International Inc.
125 McGovern Drive, Unit #1
Cambridge, Ont., Can., N3H 4R7
Phone: 1-888-501-6508
Fax: 1-888-501-7429
Web: www.lystek.com

DESIGNED BY:	REVIEWED BY:	DRAWN BY:	DATE:
M.B.		P.R.V.	JAN 2019
SCALE: AS SHOWN	PROJECT No. -	DRAWING No. A101	

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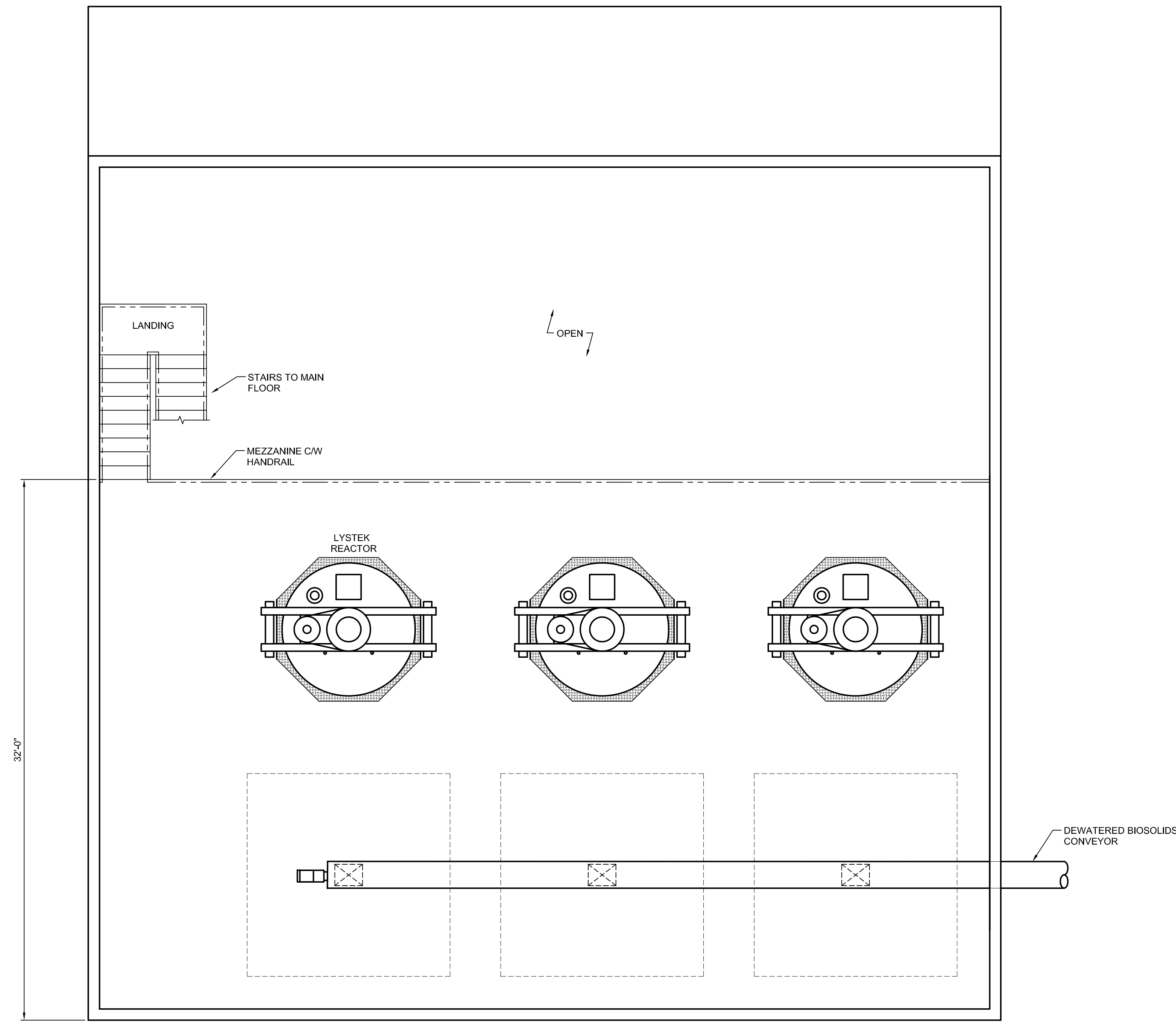

MEZZANINE LEVEL PLAN

SCALE BAR 0 5' 10' 15'

CONCEPTUAL

Automated Engineering Technologies Ltd.
91A Duke Street, Guelph, Ontario N1E 5L1 (519)821-8644
397 Romeo Street S., Stratford, ON, N5A 4V1 (519)273-9318 WEB: www.autoengtech.on.ca

No.	REVISION	DATE

APPROVED BY:

LYSTEK OMRC FACILITY

PROPOSED FACILITY LAYOUT
LY10 x 3
MEZZANINE LEVEL PLAN
(CONVEYOR FEED OPTION)

Lystek International Inc.
125 McGovern Drive, Unit #1
Cambridge, Ont., Can., N3H 4R7
Phone: 1-888-501-6508
Fax: 1-888-501-7429
Web: www.lystek.com
Lystek www.lystek.com

DESIGNED BY:	REVIEWED BY:	DRAWN BY:	DATE:
M.B.		P.R.V.	JAN 2019
SCALE: AS SHOWN	PROJECT No. -	DRAWING No. A102	

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APPENDIX I

LysteGro Product Management

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LysteGro Product Management

Pictured above: Using the liquid vacuum system take away the need to stockpile biosolids in the field prior to application, thus reducing odor and loading/unloading times.

Pictured above: Standard liquid manure injection equipment is used to apply LysteGro

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APPENDIX J

Advantages of LysteGro

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Lystek
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Everything to gain.

Advantages of LysteGro

Class A Quality, High Solids Liquid Biosolids Fertilizer

The Lystek Thermal Hydrolysis Process (Lystek THP®) technology produces a concentrated high solids liquid product, LysteGro®, that is considered a Class A biosolids in the US and a registered fertilizer with the Canadian Food Inspection Agency (CFIA) in Canada. LysteGro has a solids content that generally ranges from 13 – 16% with a viscosity below 10,000 centipoise. This means that it is fully pumpable using traditional liquid manure handling and application equipment.

There are several advantages to producing and managing a Class A quality, high solids liquid

Simple and Cost Effective Liquid Pumping and Storage Systems

Pumping LysteGro from processing to storage, and from storage to truck loading is completed with standard pumps proven within the industry. This allows for rapid, familiar and low maintenance pumping operations, and accurate quantification of the volumes. Liquid solutions offer automation that is not possible compared to solid loading operations which often required manned loading equipment. Concentrated liquid storage solutions reduce real estate footprint compared to solid options as storage tanks can be constructed with practically unlimited vertical storage capacity unbound by the slumping properties of dewatered biosolids.

Transportation Loading and Unloading Efficiencies

Depending on the site requirements, loading of tanker trucks can be completed quickly (5 – 10 minutes at larger facilities) and accurately. Additionally, in the field, the product can be transferred to the application tank in the field in as little as 5 minutes. The result is an efficient and clean program at both the loading and field sites with minimal staffing requirements.

Odor Mitigation with Enclosed System

From the point of production to application in the field, the product is contained within enclosed reactors, piping systems, storage, tanker trucks, and finally the soil. Lystek THP generates minimal process air compared to dry alternatives which require the evaporation of water, and the liberation of odorous compounds that must then be captured and treated. This is a significant advantage when managing odor throughout the life cycle of the process.

Efficient and Cost-Effective Land Application

Due to the loading methods at the and in the field, LysteGro application programs are highly efficient. At the field, the product is transferred directly from the highway tanker to the application tanker and injected into the soil subsurface, requiring only one pass. This translates to less equipment, less staffing, and less time spent on fields.

Application Accuracy and Nutrient Use Efficiency

The application rate is controlled with flow meters to ensure it is placed evenly and accurately throughout the field. This provides confidence that the customer can rely on the material as a synthetic fertilizer replacement. This also creates opportunities for farmers to utilize their GPS technology to place the seed close (within 2" for example) to the band of LysteGro to optimize carbon and nutrient use efficiency. The sub-surface injection of the product minimizes nitrogen loss, maximizing the effective nutrient value of the product.

Environmental Protection

LysteGro is sub-surface injected, which increases soil contact, and removes the risk of run-off. Additionally, because the material is concentrated, there is a dramatic reduction in the overall water volume applied per acre versus traditional liquid programs. As a result, application above the hydraulic loading rate of the soil is not a concern with this product.

Improved Optics (Out of Sight, Out of Mind)

Injection of the product minimizes soil disturbance and the outcome is a professional job with little product on the soil surface, avoiding public nuisance and concern.

Value Proposition for the Farmer

The value proposition to the farmer is to provide a consistent quality product they can rely on to improve yields and reduce input costs. LysteGro is enhanced with potassium during the treatment process, adding further benefit to the farmer. The Lystek approach to fertilizer management is preferred by farmers compared with historical application methods, as it only requires one pass to inject and incorporate the product. Additionally, it is compatible with minimum till systems, which are rapidly growing in popularity in agricultural systems throughout North America.

LysteGro
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APPENDIX K

Third Party Trial: 2015 Georgian Central Soil and Crop Improvement Association Project

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LysteGro
Biofertilizer

Meeting Corn Nutrient Needs with LysteGro Fertilizer

2015-2017 Georgian Central Soil & Crop Improvement Association Project

From 2015-2017, Lystek International participated in a trial with the Georgian Central Soil and Crop Improvement Association (GCSCIA) to evaluate the effectiveness of LysteGro, in comparison to commercial fertilizer.

WHAT IS LYSTEGRO®?

Lystek utilizes its innovative technology to process biosolids and other organics to produce a high quality, pathogen free, CFIA-registered fertilizer product, LysteGro.

LysteGro has proven to be extremely popular due to the high concentrations of Nitrogen (N), Phosphorus (P) and Potassium (K) (6-8-2 on a dry weight basis OR 73-88-23 lbs/1,000 imperial gallons). Approximately 75% of the N is in organic forms, which will be slowly mineralized over time (40% of organic N mineralized in year 1, OMAFRA). LysteGro also contains a variety of other micro and macronutrients (Sulfur, Calcium, Magnesium, Zinc), as well as organic matter.

Figure 1. LysteGro® sampling

THE TRIAL

The project evaluated yield, grain protein content and late season stalk nitrate content of corn fertilized with 2 rates of LysteGro fertilizer (3,000 and 4,500 imperial gallons/acre) injected pre-plant compared to commercial fertilizer. The trial was undertaken at 12 separate sites over the 3-year period in Wellington, Grey, Simcoe, and Dufferin counties. Each site had corn planted, and samples were taken throughout the year for soil N status and plant nutrients. Yield was measured using a weigh wagon for each replicate individually to determine a mean yield for each treatment at each site.

RESULTS

In in both 2015 and 2016, with the exception of 1 site, stalk nitrate concentrations were highest in the 4,500 gal/ac LysteGro application rate, and lowest in the commercial fertilizer treatment. In 2017, both rates of LysteGro had adequate stalk nitrate levels at tasseling across all sites. According to Christine Brown (Ontario Ministry of Agriculture, Food and Rural Affairs – Field Crops Sustainability Specialist), "A stalk nitrate value under 200 ppm suggests more N may have helped the crop yield or that there was significant losses (i.e. denitrification from saturated soils) while a value over 2,000 ppm indicates more N was available at the end of the season compared to crop needs."

In all years, grain protein was higher in LysteGro treatments than in commercial fertilizer treatments when averaged across all sites. The corn grain protein content and stalk nitrate tests clearly demonstrate that there was more nitrate available later in the year in the LysteGro treatments in comparison to the commercial fertilizer treatment. This is an indication that the organic N in LysteGro is providing a slow release source of N, later in the season when the crop requires it.

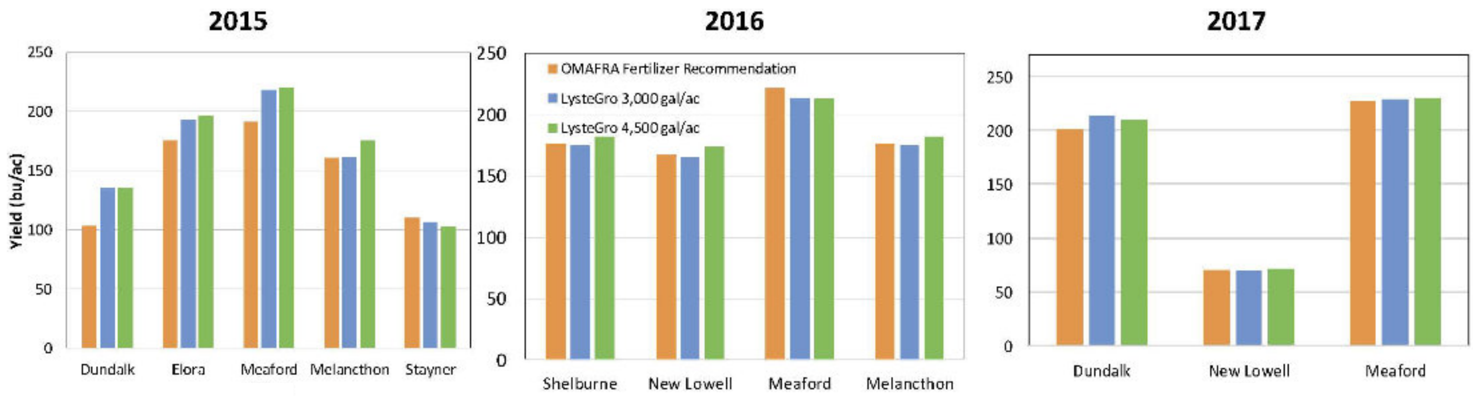

Figure 2. Yield data across 12 sites in Ontario from 2015-2017. Treatments were commercial fertilizer at OMAFRA recommended rates for 160 bu/ac corn (orange), LysteGro at 3,000 gallons/ac (blue) and LysteGro at 4,500 gallons/ac (green).

Overall, the results indicate that LysteGro at both application rates provided the nutrients required by the corn crop in all 3 years. LysteGro out-yielded the commercial fertilizer treatments by an average of 16.5 bushels/acre in 2015, 1 bushel/acre in 2016 and 4 bushels/acre in 2017. Field and weather conditions varied across the sites as evidenced by the wide range of yields. The 2015 and 2017 growing season was generally wet, with significant rainfall during the growing season, whereas 2016 was extremely dry, particularly in May and June during crop establishment. Nutrient loss and availability varies widely with soil moisture content, so the difference in precipitation may explain some of the variability in yield data between years.

CONCLUSIONS

As Christine Brown discusses in her report on this project, "these results demonstrate that LysteGro can function as a commercial fertilizer replacement for corn in Western Ontario. The corn grain protein and stalk nitrate content results also indicate, as expected, that one likely reason for the success of LysteGro is the organic N component (75% of the N in LysteGro is in the organic form), which mineralizes and releases available inorganic forms of N throughout the growing season, when the crop actually needs it. Because the useable N is released later in the year, when corn has its largest demand for the nutrient, the crop benefits as the yield potential is less likely to be limited by N availability, as can be the case with crops fertilized with conventional fertilizer" Christine also concludes that "In addition to the positive effects of the organic N within LysteGro, these trials by proxy also demonstrate that LysteGro provides the full suite of nutrients required by a corn crop, while also adding valuable organic matter and micronutrients that commercial fertilizers typically do not contain."

Figure 3. Harvesting plots in Wellington County Nov. 2017

ACKNOWLEDGEMENTS

Sincere thanks are extended to the following people: Brian Hall (retired, OMAFRA), Andrew Barrie (OMAFRA), Derek Hutchinson, Kendra Thornton & Ashwin Freyne (OMAFRA summer students), Matt Rundle (Agromart).

Thanks especially to the GCSCIA, Christine Brown (OMAFRA) and all plot cooperators.

If you have any questions related to the trial or the product, or you wish to see the full report for this project, please

contact: Simon Meulendyk
tel: 519.503.2189
email: smeulendyk@lystek.com
Twitter: @Lystek_SimonM

or

contact: Samantha Halloran
tel: 519.496.5256
email: shalloran@lystek.com
twitter: @Lystek_SamH

From:	James Dunbar <jdunbar@lystek.com>
Sent:	Wednesday, April 29, 2020 00:08
To:	Tracy Chouinard
Subject:	RE: Another Lystek Question

Tracy…
Lystek does not have a firm preference for the business model/project delivery format. Because we have to work with cities (who are usually more capital constrained) and special districts (who sometimes like to be owners (i.e., in control), we accept both cases as being equal to our business case. The part of the project model that we usually want more control over is the end-product management, but we accept shared expenses/revenue arrangements. In the case of EBMUD, with the Fairfield facility being less than an-hour away, our ability to provide on-the-spot training and support is just as good for either sceanario.

We tends to look at an annual licensing fee (roughly $50k annually) which provides ongoing support and trouble-shooting…again, having Fairfield so close, this would be discounted due to the lack of long-distance travel. But feel free to use this as budgetary filler.

James Dunbar, P.E.
General Manager/
Business Development Manager - California

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Lystek International Ltd
1014 Chadbourne Road
Fairfield, California 94534-9700
United States of America

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www.lystek.com

From: Tracy Chouinard <tchouinard@BrwnCald.com>
Sent: Tuesday, April 28, 2020 1:24 PM
To: James Dunbar <jdunbar@lystek.com>
Subject: Another Lystek Question

EXTERNAL EMAIL, PROCEED WITH CAUTION.

HI Jim,

Does Lystek have a preference on how they deliver a project? Meaning, do they prefer a design build own operate model or do they not have a preference? Also, in the capital it said that it was for the equipment and licensing fee. Is there an annual licensing fee or is a 1 time deal?

Thanks,
Tracy

Tracy Chouinard, PhD, PE*
Associate Environmental Engineer
Brown and Caldwell | Andover, MA
tchouinard@brwncald.com
T 978.983.2047

Brown AND Caldwell

Registration in specific states

BIOFORCETECH Corporation

Bioforcetech Biosolids to Energy and Biochar

Code: BFT-Q-20-417

Date : 04/02/2020

Project	**Biosolids to Energy and Biochar Facility**
Input	10,000 wet tons/year of Biosolids at 24% solid content
Output	~1,200 tons/year of Biochar

Client info:

Name	Tracy Chouinard
Company	Brown and Caldwell
Email	tchouinard@brwncald.com
Phone	978.983.2047
Client	EBMUD

Bioforcetech contacts:

Name	Valentino Villa, COO
Company address	1400 Radio road Redwood City , California 94065
Phone	+1 (650)906-0193
Email	info@bioforcetech.com
Website	http://bioforcetech.com

Document index:

BIOFORCETECH
Corporation

COVER LETTER

Dear Tracy,

Bioforcetech Corporation would like to thank you for the opportunity to serve as your biosolids solution and service provider.

Bioforcetech is in the business of providing biosolids solutions using two efficient and high value processes, the Biodryer and the “P series” Pyrolysis Units. While the equipment can be used independently, the BioDryer and Pyrolysis units are most effective when configured together as an integrated system.

BFT-BioDryer

The Bioforcetech BioDryer is a unique technology that is designed to dry biosolids in order to produce a nutrient rich Class A organic material. The resulting product can be recycled and applied as a fertilizer or soil amendment.

The BFT-BioDryer can save up to 70% in energy costs compared to a conventional belt or paddle dryer since it uses the metabolic energy of bacteria that naturally occur in biosolids, instead of costly fossil fuels. Each BFT-BioDryer unit is able to dry 8 wet tons of biosolids at 20% TS in as quick as 48 hours. The result is Class A biosolids at 75-90% TS. The BFT-Biodryer is a modular configuration allowing units to be added to increase capacity and production of rich organic material.

BFT-Pyrolysis Units (P-THREE & P-FIVE)

“Pyrolysis” is the thermochemical decomposition of organic material through the application of heat without the addition of extra oxygen. Through pyrolysis Bioforectech is able to recuperate value from biosolids, transforming it into renewable energy and biochar. Biochar is a carbon based product that is no longer considered a biosolid. Biochar produced from the BFT-Pyrolysis has economic value and can be sold as a fertilizer or as a material that can be used to make sustainable products.

BFT’s pyrolysis system is provided in two configurations, the P-THREE and P-FIVE units. Both are self-sustained pyrolysis systems that generate enough energy to maintain the process, and additional thermal energy that can be recirculated back to the BioDryer for additional biosolids drying.

A complete Bioforcetech system helps municipal wastewater treatment facilities to meet their sustainability goals by “producing” a valuable product, rather than costly waste.

The Bioforcetech systems are small, modular, and self-contained for easy installation and maintenance, as well as fully automated for 24/7 operation with little to no operator interaction.

BIOFORCETECH
Corporation

We look forward to working with you and EBMUD on this and future projects. Feel Free to contact me or our local Representative with any questions.

Best regards,

Valentino Villa
Chief Operating Officer
P: 650-906-0193
E: v.villa@bioforcetech.com

ABOUT BIOFORCETECH

OUR MISSION

Bioforcetech is committed to protecting nature and human health by providing technologies that deliver a zero waste future, transforming organic waste into sustainable products. Due to the traditional (and not cost-effective) methods for the treatment of these materials, BFT has created a new generation of machinery able to use up to 90% less energy. The BFT machinery has a limited environmental impact and is able to **obtain by-products with economic and commercial value**. BFT has developed the BioDryer and the P-Series pyrolysis reactor.

BFT is a subsidiary company of the **Presezzi Extrusion Group** (www.presezziextrusiongroup.com). The Group is based in Europe, and operates in various fields such as mechanical and renewable energy. Currently the PE group is a leader in the construction of aluminum extrusion presses, aggregate handling, industrial pyrolysis and industrial automation. In the decades of operations, the PE Group has developed a wide network of top brand partners in order to assure **the highest quality in every product.**

OUR TEAM

Founded in 2012, after years of research and pilot testing, our team has developed and deployed the first energy positive system that **UpCycles biosolids into energy and biochar**.
All this was possible due to our team of talented individuals who possess tremendous skills, which range from biotech, engineering and mechanical energy, industrial automation, financial management and business administration. With more than 20 pyrolysis installations in Europe, and the first full scale biosolids to energy system in Redwood City (CA), Bioforcetech assures that its team possesses the highest expertise and competence.

GROUP
www.presezziextrusiongroup.com

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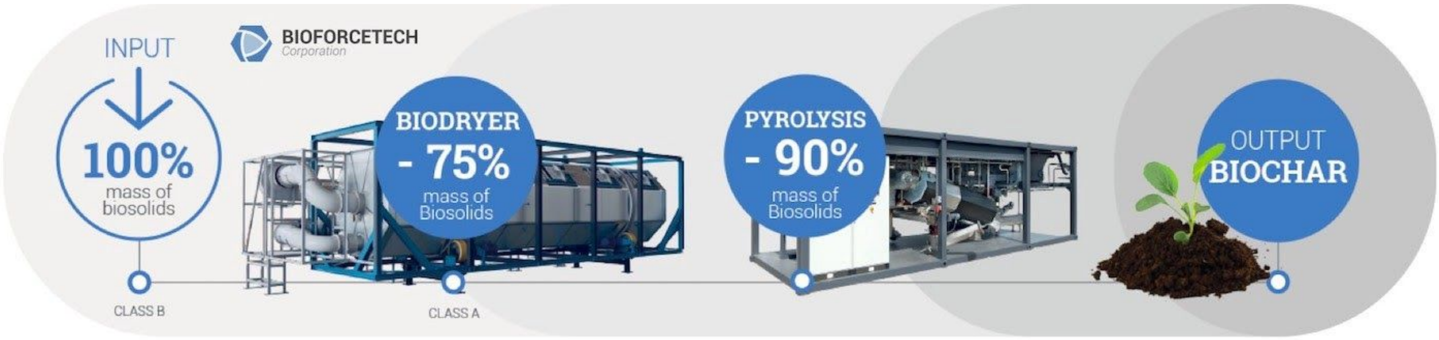
TECHNOLOGY OVERVIEW

From organic waste to value. The Bioforcetech system generates renewable energy, and UpCycles any organic waste into Biochar.

The BioForceTech (BFT) plant was designed and built to combine a low energy consumption drying process (mediated by bacterial activity), with a system to add value to biosolids (through a pyrolysis process), in order to obtain a plant having a positive energy balance.
BFT's ultimate objective was to build a high efficiency plant with low capital cost and limited external fossil fuel requirements.

Special features were implemented in the design to keep energy waste to a minimum. These include aeration, waste heat recovery, efficient reactor shape , and insulation methods.
Unlike most biosolids drying systems, which use high energy consumption to achieve high drying levels, the BFT drying system guarantees a high degree of drying (from 20% of dry matter to 80% of dry matter). This is accomplished by recycling the metabolic waste energy, generated by bacteria already present in biosolids, as heat.

An energy recovery system (pyrolysis reactor) makes the process sustainable and efficient. Installed downstream of the dryer, this system minimizes the use of outside energy for the complete treatment of biosolids from the wastewater treatment plant.



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UPCYCLE YOUR WASTE: GENERATE BIOCHAR

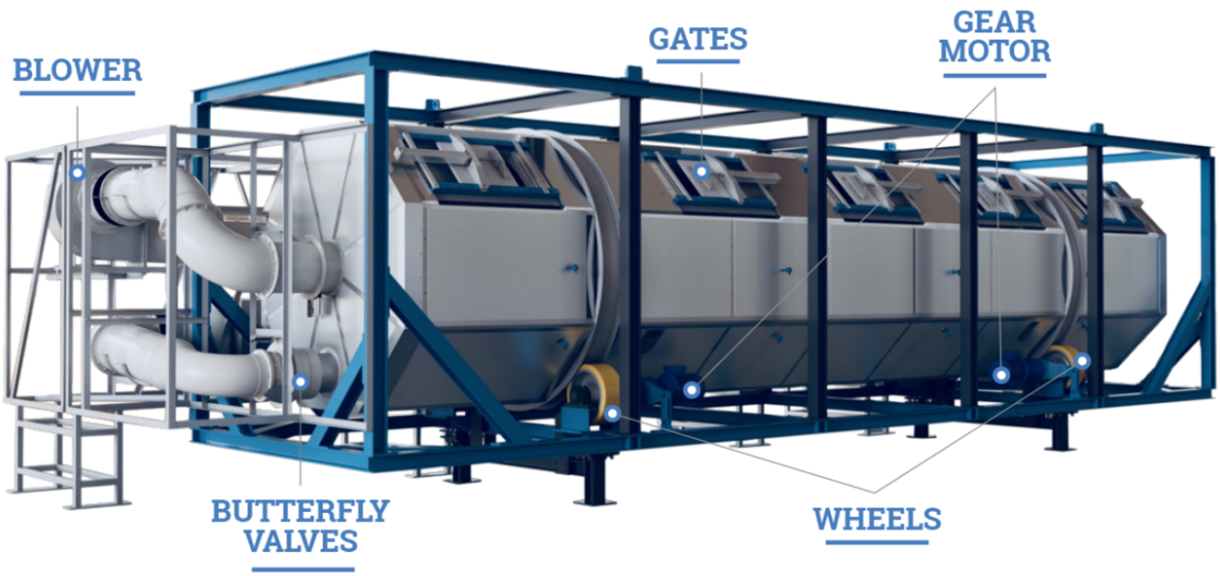
"Upcycling, also known as creative reuse, is the process of transforming by-products, waste materials, useless, or unwanted products into new materials or products of better quality or for better environmental value."

At Bioforcetech we embrace this concept and realize it with our sustainable system, converting organic waste into renewable energy and biochar.
Biochar is charcoal used as a soil amendment. Biochar is a stable solid rich in carbon, and can endure in soil for thousands of years. Biochar thus has the potential to help mitigate climate change via carbon sequestration.

Process benefits:

- ✓ UP TO 90% VOLUME REDUCTION
- ✓ 90% LESS TRUCKS
- ✓ UP TO 100% LESS ENERGY CONSUMPTION
- ✓ FULLY AUTOMATED SYSTEM
- ✓ IMPROVED ENVIRONMENTAL AND SOCIAL IMPACT
- ✓ LOW O&M

BIODRYER



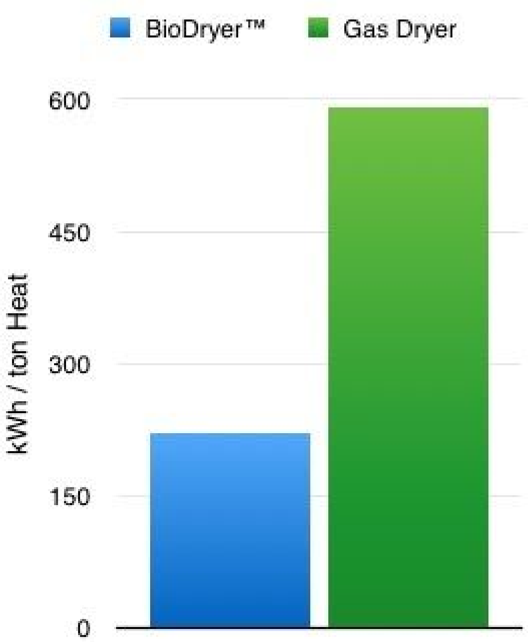
The BFT innovative process is able to dry (i.e., remove the water from) various types of biomass without the use of additives, such as fossil fuel energy, chemicals, etc. In a little over 48 hours, the BFT BioDryer dries organic materials from 20% solid content to 80% solid content and above.
Use of the naturally-occurring microbial populations is the essence of our exclusive technology. By taking advantage of the microbial populations that proliferate inside high-concentration organic materials, our team has designed an extremely fast bioreactor that promotes life inside the biomass. As the bacteria grow, they emit heat that BFT uses to remove the water and tap the stored energy.

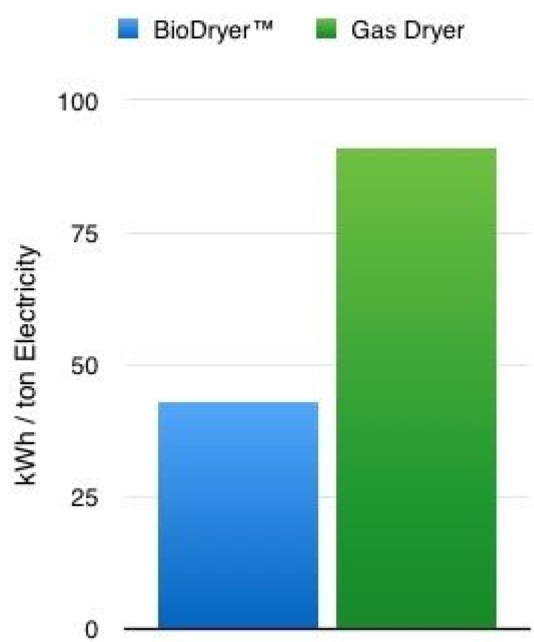
The bacteria use carbon compounds found in the biosolids to grow and reproduce. The microorganisms also need oxygen present in the air to complete these reactions. Waste heat is released during the reactions.
These metabolic reactions alone can significantly increase the temperature inside the reactor in a few hours. In a system optimized for this purpose such as the BFT BioDryer, this temperature, together with a correct air flow, are used as the means to carry and evaporate the water held by the material, thus leading to a high dry solids concentration.

Equipment:

The BioDryer is composed of an external structure that is made with painted steel to prevent rust corrosion and strength loss, and internal parts that are made of AISI 304L and AISI 304 stainless steel.
The AISI 304L is used when a welding process is needed. The stainless steel prevents fast deterioration. The reactor looks like an octagonal rotating drum and is moved by a motor reducer and linked to an aeration system. Loading and unloading gates are present on one side of the octagon.
The air system is composed of two blowers, polypropylene (PPH) pipes, and one heat exchanger. The first centrifugal fan blows the air inside the reactor and provides oxygen for the process. The second blower sucks the exhaust air and the steam formed during the process.
The PPH guarantees resistance to aggressive chemical agents and also has a good resistance to high temperatures, up to 230°F.

Batch capacity	16,000 lbs
Batch duration	48 to 56 hours
Operating Temperature	up to 160°F
Empty weight	12,000 lbs
Rotating motor	18 kW
Blower power	up to 7.5 kW





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BFT BIODRYER TECHNICAL SPECS

Volume capacity	**26 m3** (812ft3)
Max material treatment capacity per batch	**7,250 kg** (16,000 lbs / 8 ton)
Max weight (machine + material)	**23,000 kg** (50,700lbs / 25.3 ton)
Material accepted	**Biosolids - Manure - Organic Waste**
L x W x H	**12 x 3 x 2.5 m** (40 x 10 x 8 ft)
Operating condition outdoor	**0 to 55 °C** (32 to 130 °F)
Electrical certification	**UL or CE**

BFT BIODRYER SITE REQUIREMENTS

Surface preparation requirements	**Flat Concrete Pad**
Electrical connection	**100 Amp, 3 phase, 480V, 60Hz**
Compressed air	**8 bar (120 PSI)**
Sewage connection	**Required**

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BFT BIODRYER TECHNICAL PERFORMANCE

Type of process	**Batch**
Batch duration	**48h to 56h**
Operating temperature	**Up to 70 °C (160 °F)**
Yearly operating time	**8,000 Hours**
Max yearly material inlet per machine	**1,180 metric ton/y (1,300 ton/y)**
Max yearly material outlet per machine	**296 metric ton/y (326 ton/y)**
Min material solid content inlet	**17% SC**
Material solid content outlet	**From 70 to 90% SC**
Material output category (biosolids)	**Class A / Exceptional Quality**
Emission	**Compliance with California Limits**
Lifespan	**30 years**

P-Series TECHNOLOGY OVERVIEW

Pyrolysis is the thermochemical decomposition of organic material through the application of heat without the addition of extra oxygen. Through this process, which takes place at temperatures between 660 and 1,650 degrees F, two CO-products are obtained: syngas and char. Our P-Series Pyrolysis machines utilize this principle to produce renewable energy from any organic waste.

SELF-SUSTAINED PYROLYSIS

Once the pyrolysis process operating temperature is reached, the exhaust gases from the combustion chamber are passed through the annular space between the central tube and the outer casing of the pyro-reactor, ensuring the temperatures required to perpetuate the pyrolysis process. The 24/7 process becomes self-sustained.

SUSTAINABLE BIOCHAR PRODUCTION

The only by-product of our pyrolysis system is biochar. Biochar is a high carbon material used as a soil amendment. Biochar is a stable solid rich in carbon, and can endure in soil for thousands of years. Biochar thus has the potential to help mitigate climate change via carbon sequestration. In addition, as a soil amendment biochar can increase soil fertility, agricultural productivity, and water retention, and drastically reduce nutrient run-off.

ONE MACHINE, MULTIPLE FEEDSTOCK:

The P-Series pyrolysis machines were designed for biosolids treatment, but these systems are also able to treat a wide range of materials or mix. The BFT pyrolysis can process biosolids, manure, green waste, green waste/biosolids mix, food waste and most organic waste.

BURNING WITHOUT FLAME - ENVIRONMENT BENEFITS

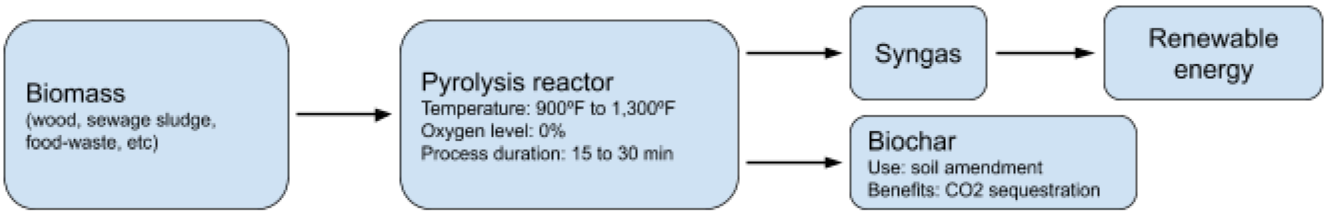
The BFT Pyrolysis machine has been designed to achieve the maximum production of gaseous material. The gas is immediately burnt in a special flameless reactor. Burning the produced syngas without flame allows a lower combustion temperature, resulting in lower NOx emissions. Thanks to this special technology, the BioForceTech P-FIVE Pyrolysis system has been approved by EPA as a non-incineration process. The BFT P-FIVE is the first pyrolysis process for biosolids that has been approved by EPA and that meets the emission requirements for EPA and California regulations.

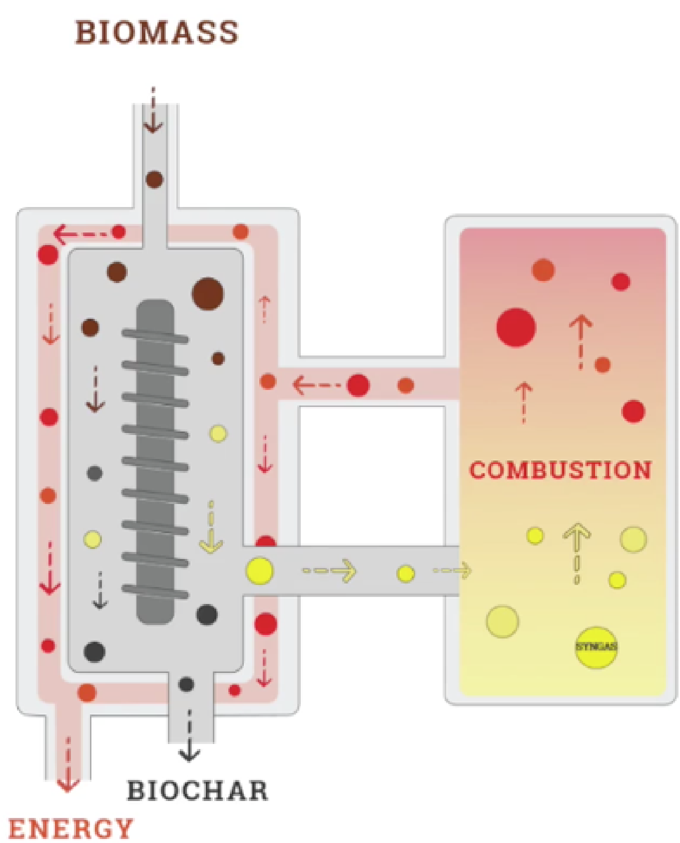
EQUIPMENT:

The P-Series pyrolysis systems are pre installed inside a custom-designed shipping container that is easy to transport and ready for installation. Like the Bio-Dryer, The BFT pyrolysis system requires only a flat cement pad for installation and does not need protection from the elements. The structure contains all the required parts: pyrolysis reactors, flameless burner, char discharge conveyor, 2 heat exchangers, blowers, electrical panel and automation with safety UPS system, heat dissipation radiators, wet scrubber for SO_2 removal, activated carbon filter, 2 cyclones (particulate abatement devices) and a chimney with sample ports for analysis.

PYROLYSIS

Pyrolysis is the thermochemical decomposition of organic material through the application of heat without oxygen. Because no oxygen is present the **material does not combust** but the chemical compounds (i.e. cellulose, hemicellulose and lignin) that make up that material **thermally decompose into combustible gases and biochar**.





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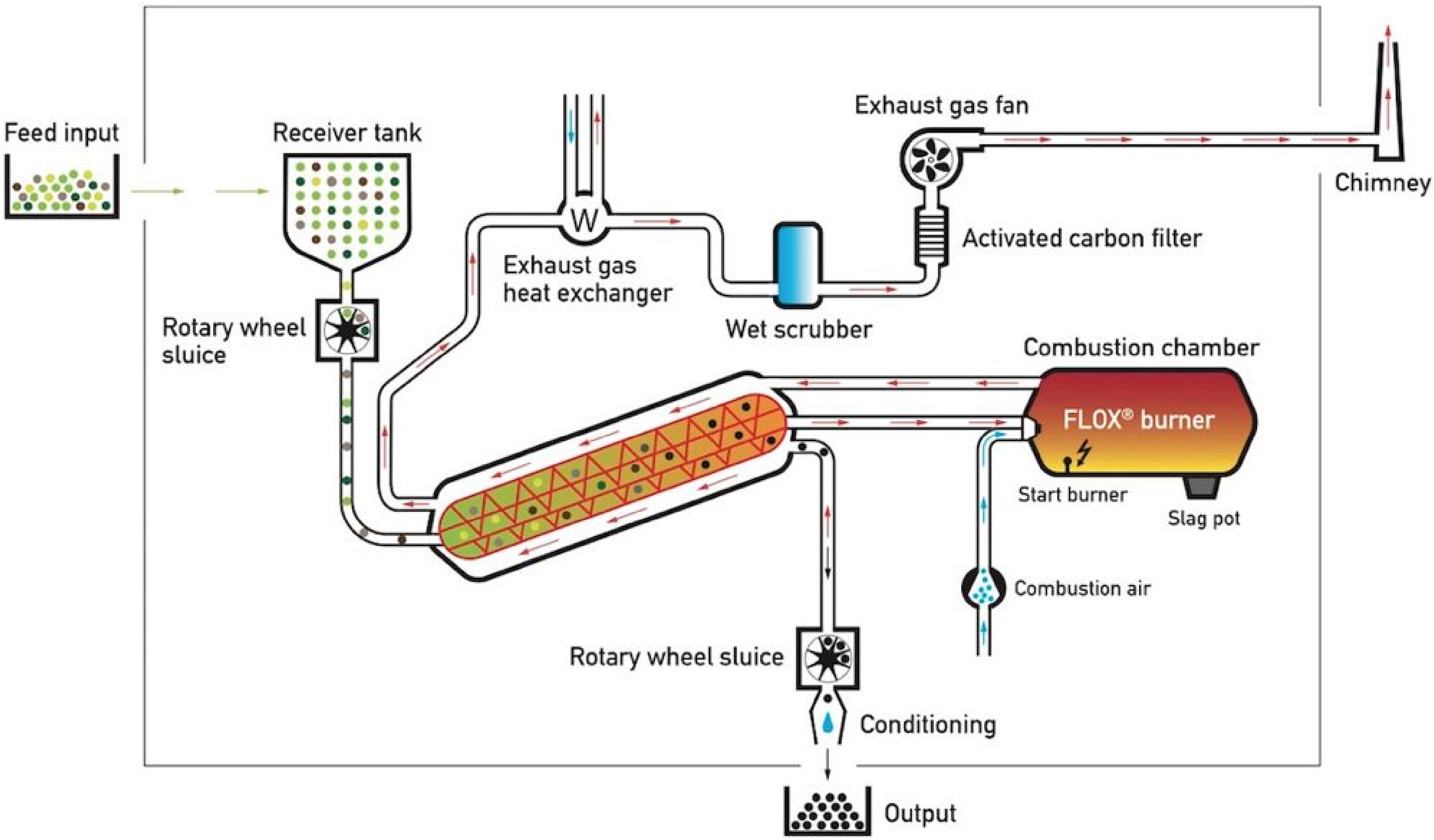
BFT P-Series PYROLYSIS UNITS

P-Series Pyrolysis machines utilize the principle of pyrolysis to produce renewable energy and biochar from any organic waste.

SELF-SUSTAINED PYROLYSIS

Once the pyrolysis process operating temperature is reached, the exhaust gases from the combustion chamber are passed through the annular space between the central tube and the outer casing of the pyro-reactor, ensuring the temperatures required to perpetuate the pyrolysis process. The 24/7 process becomes self-sustained.



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BURNING WITHOUT FLAME - ENVIRONMENT BENEFITS

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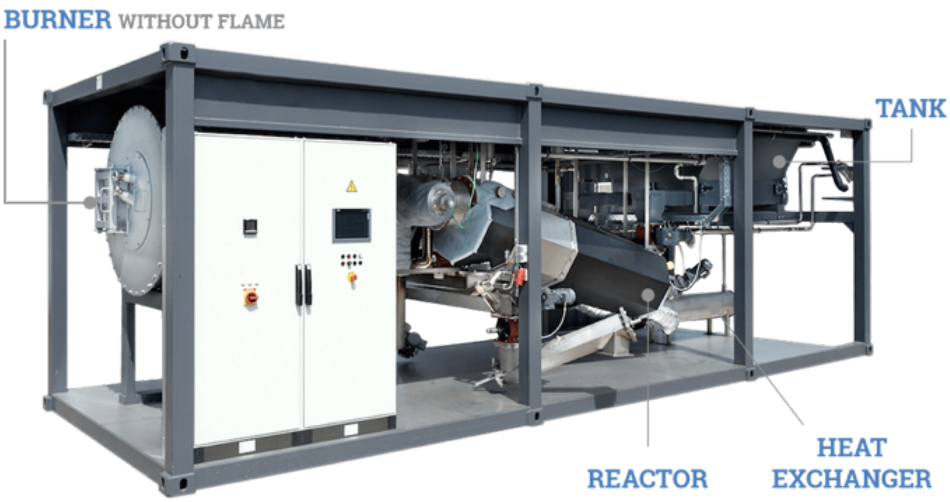

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BFT P-Series TECHNICAL SPECS

	P-FIVE	P-THREE
Reactor weight	**21,000 kg** (46,300 lb / 23.1 ton)	**31,000 kg** (68500 lb / 34.3 ton)
Max weight (reactor + material)	**23,000 kg** (50,700 lb / 25.3 ton)	**34,500 kgs** (76,000 lb / 38 ton)
Total Installed Power	**40 kW** (53.6 HP)	**70 kW** (94 HP)
L x W x H Reactor	**9 x 3 x 2.8 m** (29'-6" x 9'-10" x 9'-4")	**12 x 3 x 5.8 m** (39'-5" x 9'-10" x 19")
L x W x H Technical Container	**6 x 3 x 4.9 m** (19'-8" x 9'-10" x 16')	**6 x 3 x 5.8 m** (19'-8" x 9'-10" x 19")
Operating Condition Outdoor	**0 to 55 °C** (32 to 130 °F)	**0 to 55 °C** (32 to 130 °F)
Electrical Certification	**UL or CE**	**UL or CE**
Material Accepted	**Biomass-Biosolids-Organic Waste (not Municipal Solid Waste)**	**Biomass-Biosolids-Organic Waste (not Municipal Solid Waste)**
Biochar Production	**Yes**	**Yes**
Energy production	**Yes, Thermal**	**Yes, Thermal**
Bio-Oil production	**No**	**No**

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BFT P-Series TECHNICAL PERFORMANCE

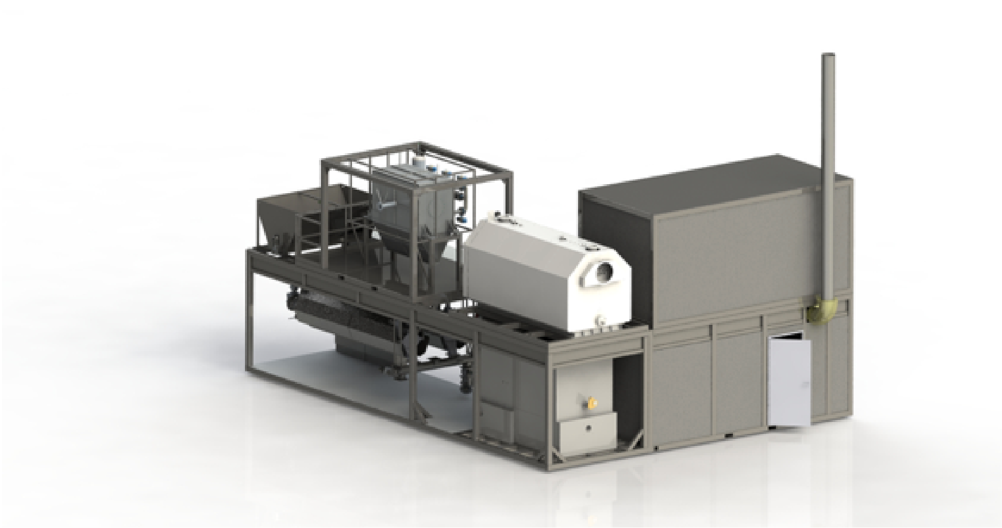
	P-FIVE	P-THREE
Type of process	**Continuous Process 24/7**	**Continuous Process 24/7**
Yearly operating time	**8,000 Hours**	**8,000 Hours**
Operating temperature	**From 350 to 720 °C** (from 660 to 1,330 °F)	**From 350 to 720 °C** (from 660 to 1,330 °F)
Min Residence time	**10 min**	**10 min**
Max material treatment Capacity	**200 kg/h** @ 60% SC (440 lb/h @ 60% SC)	**600 kg** @/h 60% SC (1,320 lb/h @ 60 SC)
Min material Treatment Capacity	**55 kg/h @ 95% SC** (120 lb/h @ 95% SC)	**165 kgs/h @ 95% SC** (365 lb/h @ 95% SC)
Max material Inlet per year	**1,600 metric ton/y** (1,760 ton/y)	**4,800 metric ton/y** (5,290 ton/y)
Max Biochar Outlet per year	**640 metric ton/y** (716 ton/y)	**1,920 metric ton/y** (2,115 ton/y)
Min Material Solid Content Inlet	**50% SC**	**50% SC**
Material Particle SIze	**Max 2.5 cm every direction (1 inch every direction)**	**Max 5 cm every direction (2 inch every direction)**
Material Solid Content Outlet	**Above 90% SC**	**Above 90% SC**
Material Output Category (biosolids)	**High Quality Biochar**	**High Quality Biochar**
Thermal Energy produced	**150 kW** **(512,000 BTU/hr)**	**450 kW** **(1.5 MMBTU/hr)**
Emission	**Compliance with EPA**	**Compliance with EPA**
Lifespan	**30 years**	**30 years**

BIOFORCETECH Corporation

BFT P-Series SITE REQUIREMENTS

Surface Preparation	**Flat Concrete Pad**	**Flat Concrete Pad**
Electrical Connection	**90 Amp, 3 phase, 480V, 60Hz**	**150 Amp, 3 phase, 480V, 60Hz**
Compressed Air	**7 bar (100 psi)**	**7 bar (100 psi)**
Water connection	**½"pipe**	**2" inch pipe**
Sewage Connection	**2" pipe**	**4" pipe**
Natural Gas/GPL	**1" pipe, 20 to 35 inch of water**	**2" pipe, 20 to 35 inch of water**

Dimension P-Three Reactor



Footprint
Main Reactor: 40 x 10 x 19 ft
Gas Cleaning Container: 20 x 10 x 19 ft

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BIOCHAR

Biochar is a high-carbon, fine-grained residue that today is produced through modern pyrolysis processes.

In recent years, multiple university researchers have paid particular attention to biochar, for it's soil remediation properties and climate benefits.

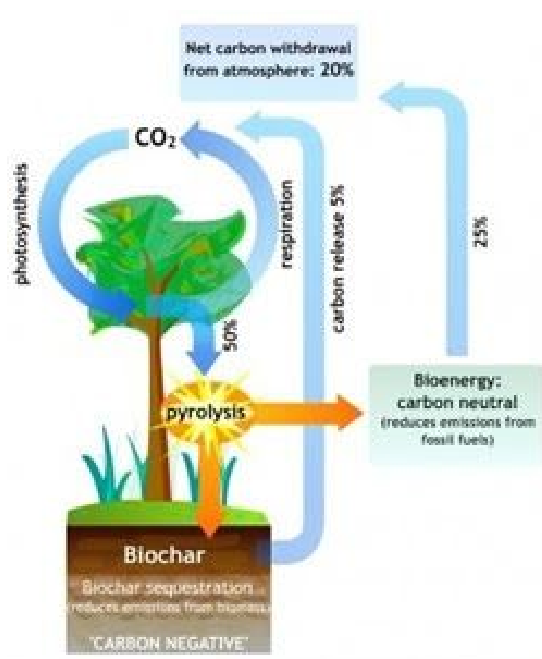
Biochar can be distinguished from charcoal, which is used mainly as a fuel. Biochar is primarily used as a soil amendment to improve soil functions and to reduce emissions from biomass that would otherwise naturally degrade to greenhouse gases.

Biochar and the climate challenge

Fossil fuels are carbon positive; they add more carbon dioxide (CO2) and other greenhouse gases to the air and thus exacerbate global warming. Ordinary biomass fuels are carbon neutral; the carbon captured in the biomass by photosynthesis would have eventually returned to the atmosphere through natural processes like decomposition. Sustainable biochar systems can be carbon negative by transforming the carbon in biomass into stable carbon structures in biochar which can remain sequestered in soils for hundreds and even thousands of years. The result is a net reduction of CO2 in the atmosphere.

Carbon in biochar can persist in soils over long time scales. Beyond the carbon sequestered in the biochar itself, biochar incorporated in soils also offers numerous other potential climate benefits.

1. **Soil Fertility**: Biochar can improve soil fertility, stimulating plant growth, which then consumes more CO_2 in a positive feedback effect.
2. **Reduced fertilizer inputs**: Biochar can reduce the need for chemical fertilizers, resulting in reduced emissions of greenhouse gases from fertilizer manufacture.
3. **Reduced N_2O and CH_4 emissions**: Biochar can reduce emissions of nitrous oxide (N_2O) and methane (CH_4)—two potent greenhouse gases—from agricultural soils.
4. **Enhanced soil microbial life**: Biochar can increase soil microbial life, resulting in more carbon storage in soil.
5. **Reduced emissions from feedstocks**: Converting agricultural and forestry waste into biochar can avoid CO_2 and CH_4 emissions otherwise generated by the natural decomposition or burning of the waste.



IMPLEMENTATION CONSIDERATIONS

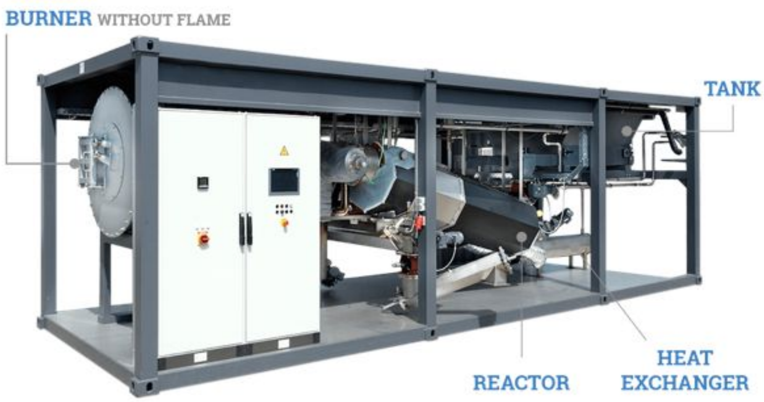
Regulatory implications
Bioforcetech's existing biosolids plants met or exceeded all regulatory requirements.
Because our plants are lower impact than any known alternative, we have not found regulations to impede adoption of our technology. Our Redwood City, California plant has met or exceeded all EPA and Bay Area Air Quality Management District (California, USA) regulations.
Even though an air permitting process might be required, Bioforcetech is positive that this process will be fairly quick without complications. Our existing permit with the Bay Area Air Quality Management District has created a roadmap for effectively permitting facilities within the jurisdiction.

Aesthetics (odor, noise, visual impact, etc.)
Bioforcetech's existing biosolid plants reduce all impacts. Because our plants are lower impact than any known alternative, we have not found aesthetic, visual, odor, noise, cultural, or other impacts to impede the adoption of our technology. Our Redwood City, California plant is so quiet and low impact that guests actually ask if the plant is on. The operation of the plant makes no more noise than the operation of your car.

EPA — Got EPA approval for a NON-Incineration thermal process

Bay Area Air Quality Management District — Got a permit to operate in the toughest Air district in the USA

CalRecycle — Approving the BFT Pyrolysis technology as a "landfill diversion method"



First Pyrolysis of Sewage Sludge Permitted in the USA!

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PLANT DATA - BioDryers + P-THREE Pyrolysis Unit

Plant requirements:

Input material: biosolids at 24% solid content
Additional feedstock : no additional feedstock is required
Utilities required :

- Electricity (100A breaker each BioDryer and 150A each P-THREE Pyrolysis)
- Natural gas supply for backup (2 inch line, pressure 20-100 Inch of H2O), or propane tank
- Sewage connection
- Water (2 inch pipe)
- Compressed air (8 bar)

Site: The entire system can be installed outside. The only site requirement is a flat cement pad. If temperatures are lower than 15ºF, a heated building might be required to ensure proper operations

Input:	10,000 wet tons/year of biosolids, at 24% solid content
Output:	~ 1,200 tons/year of Biochar
Lifespan:	up to 30 years
Up Running time:	up to 8,000 hours/year

Estimated energy consumption:
Electricity: 55 kWh/wet ton
Heat (natural gas or propane): 0 MMBTU/h with pyrolysis (only for machine start up)

Number of BioDryers:	8
Number of P-THREE:	1
Pollution control:	Dry-scrubber, ceramic filter, caustic soda scrubber and AC filter

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in summer only need to run 1 train (25% of load). run all 4 in winter

BUDGETARY QUOTE: BioDryers + P-THREE Pyrolysis Unit

BioDryers and Ancillary Equipment
- 8 BioDryers
- BFT Standard Cleaning system for Exhaust Air from BioDryers (Dry-Scrubber)
- Top and bottom Conveyors
- Dried Biosolids storage tank with Grinders and backup conveyance for dried Class A Biosolids
- Natural Gas Boiler and Piping
- Catwalks for Maintenance Access
- BFT standard Electrical and Control Panels (non-classified environment)

Equipment cost: $4,000,000

Pyrolysis System
- 1 BFT P-THREE Pyrolysis Unit
- Pyrolysis Exhaust Gas Cleaning System
- Caustic Soda holding tank
- Conveyors to Pyrolysis Unit
- Biochar Unloading and Biochar Bagging Station
- Catwalks for Maintenance Access
- BFT standard Electrical and Control Panels (non-classified environment)

Equipment cost: $2,300,000

Services
- Shipping of All Equipment to Client's site
- Start-up and Commissioning

Services cost: $600,000

Total cost for all the above: $6,900,000

Estimated Installation Cost for the BFT Scope of Supply (utilities, cement slab and building not included): $300,000 - $500,000

Not Included in the proposal:

- Engineering support or site visit unless stated otherwise
- Conveying system from dewatering building to the BFT plant
- Light building for weather protection
- Project Management and Permitting Support
- Construction and Site Preparation
- Emission stack
- All utilities that are required for operation
- Unloading, uncrating, installation and installation supervision.
- Readiness of the Equipment before requesting start-up service. Non-readiness may incur additional charges
- Compatibility of Equipment materials of construction with process environment
- Piping connections, platforms, gratings and railings unless stated otherwise
- Bonding for the equipment
- Any other auxiliary equipment or service not detailed above
- Taxes, Duties and fees for containers held at the designated port in excess of 5 days
- Everything not included in the list above

*Estimated annual O&M cost (BioDryers + Pyrolysis): **$138,000***

O&M cost breakdown:
- Utilities: $58,000
    - (electricity @ $0.1/kWh): $55,000
    - (natural gas @$1/therm): $3,000
- Spare parts, components replacement and regular maintenance: $80,000
- Maintenance: ~500 hours/year
- Operation (24/7 - fully automated)

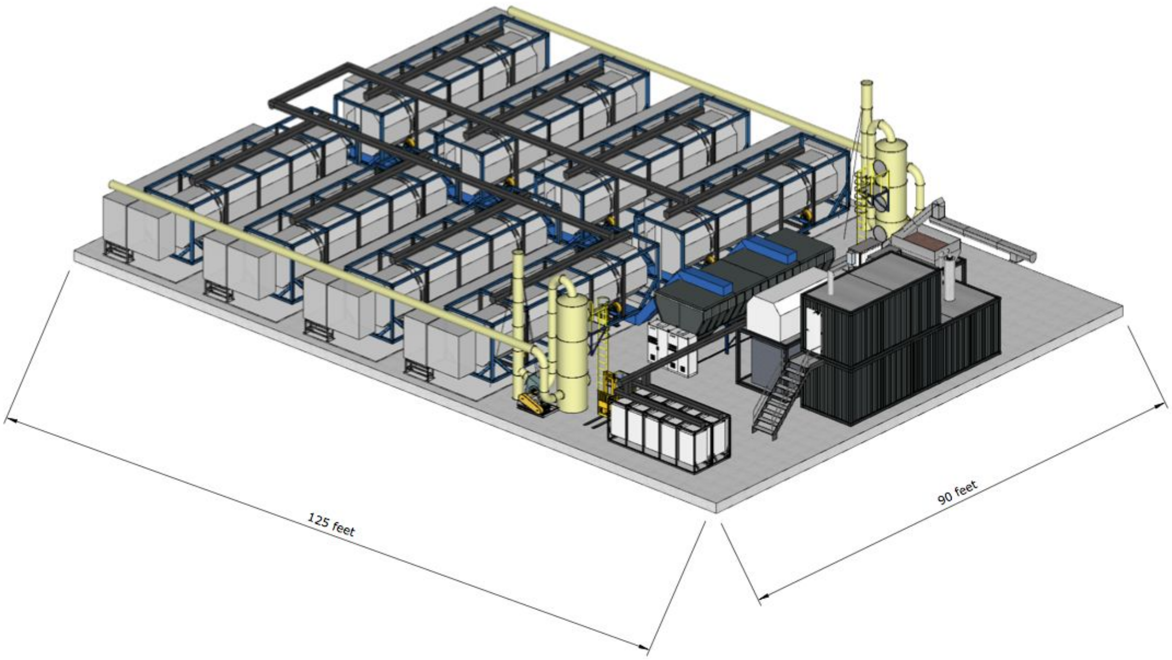
Biochar Management - BFT Full-Service Option

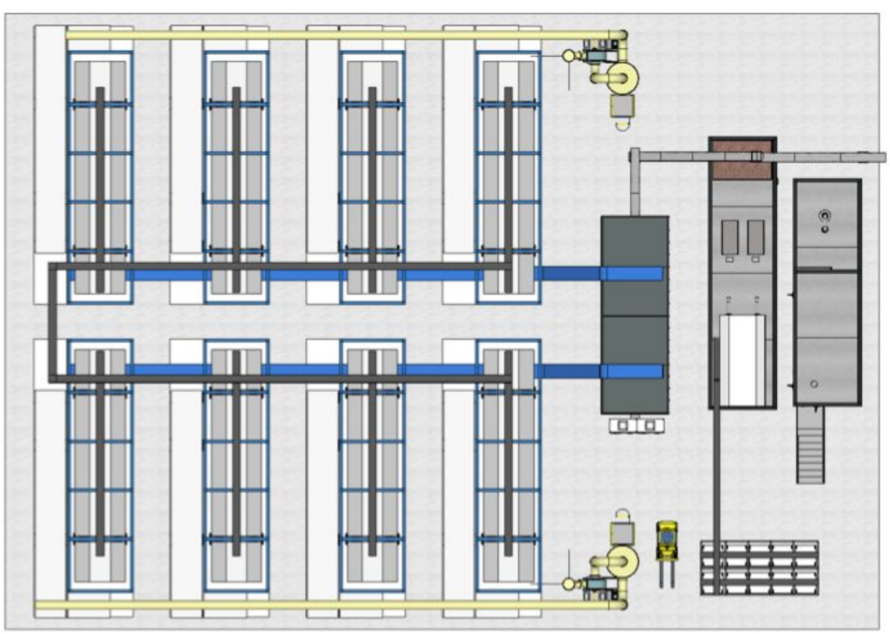
BioForceTech Corporation (BFT) guarantees a free off-take agreement (5 or 10 years with renewal option), for the whole production of Biochar. In addition, BFT offers a 5-10% revenue stream for net profits realized from the sale of the product. BFT estimates the value of biochar at **$200/ton**.

Estimate of Revenues for the City:
Total Biochar (Yearly Production): 1,200 tons
Total value: 1,200 * $200= $240,000
Cost of Sales: $50/ton
Net Profits: $150/ton

City Profit Share: ($150*0.1)*1,200= $18,000/year

PROJECT LAYOUT





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REFERENCE LIST

United States

1) Silicon Valley Clean Water; Redwood City CA
Installation date: June 2017
Full Scale: 6 BioDryers and 1 P-FIVE Pyrolysis
Feedstock: Anaerobically Digested Biosolids
Contact information: Teresa Herrera, P.E. , 650-832-6220, THerrera@svcw.org

2) Yakama Legends Casino
Installation date: January 2019
1 BioDryer for Biosolids
Feedstock: Undigested Sludge
Contact information: Kenneth Grasser
Kenneth_Grasser@legendscasino.com
+1 (509) 945-5916

Italy

1) Brianzacque SpA
4 BioDryers and 1 P-FIVE
Project phase: manufacturing in progress
ETA for commissioning: Q1 2020
Feedstock: Undigested Sludge

2) Gruppo CAP
1 BioDryer + 6 to expand the facility + 1 lab scale pyrolysis system
Project phase: Commissioned January 2020
Feedstock: Anaerobically Digested Biosolids

BIOFORCETECH Corporation

Europe (Pyreg Partner) - Biosolids

1) Entsorgungsverband Saar (EVS)
SITE Homburg
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2016

PROCESS
• Recycling of sewage sludge
• Production of phosphorus fertilizer
• Using surplus excess energy

INPUT
• Dried sewage sludge

2) WASTE WATER TREATMENT LINZ-UNKEL
SITE Unkel
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2015

PROCESS
• Recycling sewage sludge
• Production of phosphorus fertilizer
• Using surplus excess energy

INPUT
• Dried sewage sludge

3) Skanefro
SITE Hammenhög
COUNTRY Sweden
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2019

PROCESS
• Recycling sewage sludge
• Production of phosphorus fertilizer
• Using surplus excess energy

INPUT
• Dried sewage sludge

Other Biomasses

1) STOCKHOM VATTEN
SITE Stockholm
COUNTRY Schweden
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2017

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste

2) A. H. MEYER (ROESS NATURE GROUP)
SITE Tianjin
COUNTRY China
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2016

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Straw
• Coconut fiber

3) FINZELBERG GMBH & CO. KG
SITE Andernach
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2015

PROCESS
- Recycling of biomass
- Production of biochar
- Using surplus excess energy

INPUT
- Production residues

4) SITE Riedlingsdorf
COUNTRY Austria
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2011

PROCESS
- Recycling of biomass
- Production of biochar
- Using surplus excess energy

INPUT
- Green waste
- Grain husks
- Paper fiber sludge

5) FETZER ROHSTOFFE + RECYCLING GMBH
SITE Eislingen
COUNTRY Germany
NUMBER OF P-FIVE UNITS 3
IN COMMISSION SINCE 2013, 2017

PROCESS
- Recycling of biomass
- Production of biochar
- Using surplus excess energy

INPUT
- Forestry & agriculture residues
- Paper fiber sludge

6) AWASTE MANAGEMENT SOCIETY LTD. OF NECKAR-ODENWALD-DISTRICT
SITE Buchen
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2016

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste
• Various biomass

7) WASTE MANAGEMENT & CITY CLEAN FREIBURG
SITE Freiburg
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2017

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste
• Various biomass

8) GEIGER PFLANZENKOHLE UND ENERGIE GMBH
SITE Parsdorf
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2014

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste
• Forestry & agriculture residues

9) VERORA GMBH
SITE Edlibach
COUNTRY Switzerland
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2012

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste
• Screenings
• Wood chips

10) GREENPOCH (SA)
SITE Wagnelée
COUNTRY Belgium
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2016

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste

11) CARBONIS GMBH & CO. KG
SITE Garrel
COUNTRY Germany
NUMBER OF P-FIVE UNITS 2
IN COMMISSION SINCE 2016, 2017

PROCESS
• Recycling of biomass
• Production of feeding char
• Using surplus excess energy

INPUT
• wood chips

12) WEHRMANN'S LÄRCHENHOF
SITE Wurster North Sea Coast
COUNTRY Germany
NUMBER OF P-FIVE UNITS 1
IN COMMISSION SINCE 2017

PROCESS
• Recycling of biomass
• Production of biochar
• Using surplus excess energy

INPUT
• Green waste
• Various wooden material

13) Ebersbach, Germany
Install date: 2013/2016/2017
Full Scale P-FIVE Pyrolysis Units
Contact information: christoph.zimmermann@du-willkommen.de

14) Dorth, Germany
Install date: 2014/2017
Full Scale P-FIVE Pyrolysis Units
Contact information: s.schmidt@novocarbo.de

This proposal is not a guaranteed quote or scope of work--rather it is an estimate based on the best information available.

Tracy Chouinard

From: Valentino Villa <v.villa@bioforcetech.com>
Sent: Wednesday, April 29, 2020 18:04
To: Tracy Chouinard
Subject: Re: Quote request for EBMUD - need by 4/3/20

Hi Tracy,

Thanks for your follow up email.

There is no licensing fee when purchasing our equipment.
Our business model preference is selling and supporting the equipment.

We are working on many projects with DB delivery. We found that as a great way for delivering a successful project while optimizing costs. During the years, we have built trusted relationships with a local contractors, thus we can provide solid DB packages.
I just wanted to point that out for your reference and consideration.

I hope this helps.

Thank you.
Best regards,

--
Valentino Villa
COO
BioForceTech Corporation

email: v.villa@bioforcetech.com
mobile: +1 (650) 906-0193
skype: info.bioforcetech
web: www.bioforcetech.com

On Apr 29, 2020, at 7:12 AM, Tracy Chouinard <tchouinard@BrwnCald.com> wrote:

Hi Valentino,

Is there any licensing fees when purchasing the bioforectech equipment? Also, does Bioforetech have any preference on business models, e.g. design build own operate or selling and supporting the equipment?

Regards,
Tracy

From: Valentino Villa <v.villa@bioforcetech.com>
Sent: Thursday, April 23, 2020 12:32
To: Tracy Chouinard <tchouinard@BrwnCald.com>
Subject: Re: Quote request for EBMUD - need by 4/3/20

My pleasure, Tracy.
Best regards,

--
Valentino Villa
COO
BioForceTech Corporation

email: v.villa@bioforcetech.com
mobile: +1 (650) 906-0193
skype: info.bioforcetech
web: www.bioforcetech.com

On Apr 23, 2020, at 7:09 AM, Tracy Chouinard <tchouinard@BrwnCald.com> wrote:

Thank you Valentino. This is helpful.

From: Valentino Villa <v.villa@bioforcetech.com>
Sent: Wednesday, April 22, 2020 15:28
To: Tracy Chouinard <tchouinard@BrwnCald.com>
Subject: Re: Quote request for EBMUD - need by 4/3/20

Hi Tracy,

The Syngas is completely and entirely combusted within each pyrolysis unit.
The Oxidation of the Syngas happens in our special Flameless Flox Burner, at a constant and controlled temperature to keep pollutants and NOx at a very low level. This is the reason why we were able to get the Air Permit from EPA and BAAQMD.

The Syngas produced will never be available for extraction or other uses.
There will never be any type of Syngas/Bio Oil condensation because of the way we manage it.
The Oxidation happens at ~2,000ºF.

By Combusting the Syngas, we are able to produce thermal energy (exhaust gas). The resulting gas is used within the pyrolysis system to keep the process hot and self-sustained.
The remaining gas is sent to a double stage heat exchanger and transformed into hot water at 200ºF.
The hot water is saved and diverted back to the BioDryers to achieve an energy neutral or positive process from a heating standpoint (no natural gas needed to dry).

Before going to the emission stack, the exhaust gas goes through a wet scrubber (casuistic soda), and an AC filter for extremely clean air emissions.

I hope this helps but if you have any father questions, please do not hesitate to reach out.

Thanks,

--
Valentino Villa
COO
BioForceTech Corporation

email: v.villa@bioforcetech.com
mobile: +1 (650) 906-0193
skype: info.bioforcetech
web: www.bioforcetech.com

On Apr 22, 2020, at 11:39 AM, Tracy Chouinard <tchouinard@BrwnCald.com> wrote:

Hi Valentino,

Yes I am well, thank you. I hope you are well too.

What is done with the Syngas produced? It is used for heating? Or Flared?

Thank you,
Tracy

From: Valentino Villa <v.villa@bioforcetech.com>
Sent: Monday, April 20, 2020 17:39
To: Tracy Chouinard <tchouinard@BrwnCald.com>
Subject: Re: Quote request for EBMUD - need by 4/3/20

Hi Tracy,

I trust you are doing well and that you had a good weekend.

No, I would not consider water usage for cooling the biochar. It is such a small and minimal amount that can already be included in our O&M costs.
We are looking at 0.15 GPM of water/pyrolysis unit.

Thank you.
Best regards,

--
Valentino Villa
COO
BioForceTech Corporation

email: v.villa@bioforcetech.com
mobile: +1 (650) 906-0193
skype: info.bioforcetech
web: www.bioforcetech.com

On Apr 20, 2020, at 7:55 AM, Tracy Chouinard <tchouinard@BrwnCald.com> wrote:

Hi Valentino,

For Pyrolysis and the Biodryers, do I need to include any water usage for cooling the biochar? If so, how much is needed.

Thanks,
Tracy

From: Valentino Villa <v.villa@bioforcetech.com>
Sent: Tuesday, April 7, 2020 11:01
To: Tracy Chouinard <tchouinard@BrwnCald.com>
Subject: Re: Quote request for EBMUD - need by 4/3/20

Hi Tracy,

Ok will do. Thanks,

--
Valentino Villa
COO
BioForceTech Corporation

email: v.villa@bioforcetech.com
mobile: +1 (650) 906-0193
skype: info.bioforcetech
web: www.bioforcetech.com

APPENDIX G – EVALUATION CRITERIA

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<table>
<tr><th rowspan="3">Guiding Principles/ Goals</th><th rowspan="3">Objectives</th><th colspan="6">Evaluation Criteria</th></tr>
<tr><th rowspan="2">Criteria</th><th rowspan="2">Weight</th><th rowspan="2">Considerations</th><th rowspan="2">Metric(s)</th><th colspan="2">Basis for Score[a]</th></tr>
<tr><th>Initial Evaluation[b]</th><th>Detailed Evaluation[c]</th></tr>
<tr><td colspan="8">TECHNICAL</td></tr>
<tr><td rowspan="4">Maintain reliable wastewater treatment by preserving, implementing, and utilizing assets that provide sufficient treatment capacity and are resilient to changing conditions, both imminent and gradual (e.g., seismic events and sea-level rise).</td><td rowspan="2">Preserve/replace assets, maintain an efficient site layout, and optimize land utilization to facilitate reliable wastewater treatment operations and maintenance.</td><td>Efficient and Well Integrated Site Layout</td><td>6%</td><td>• Does it minimize the footprint required per mgd of influent?
• Does it leave space for future improvements, expansion, or upgrades?
• How well do future facilities integrate with existing facilities?</td><td>• Acreage of treatment facilities
• Synergies in facility placement and logical flow</td><td>Qualitative</td><td>Quantitative score scaled based on least acres of land used</td></tr>
<tr><td>Ease of Constructability</td><td>3%</td><td>• How easily can the future facilities be constructed?
• How easy will it be to continue operating the existing processes during construction?</td><td>• Simplicity of construction phasing (Simple, moderate, or complex)</td><td>Qualitative</td><td>No Change</td></tr>
<tr><td rowspan="2">Provide reliable capacity to manage and treat wastewater flows within the existing wastewater service area, such that regulations are met under a variety of operating conditions.</td><td>Technology Maturity/ Reliability</td><td>12%</td><td>• How many existing WWTPs have the proposed technology/approach?
• How large are they and how long have they been operating successfully?
• Will the treatment process be reliable and robust with respect to meeting current and future regulations under a variety of flow/load conditions?
• Does this alternative have flexibility to handle high peaking factors/wet weather flows?</td><td>• Minimal, moderate or several
o Number of installations
o Size of installations
o Years of successful, reliable operation meeting similar regulations
• Effluent quality consistently meets potential effluent limits under variable flow/load conditions</td><td>Qualitative</td><td>No Change</td></tr>
<tr><td>Flexibility/ Ease of O&M</td><td>6%</td><td>• Will O&M labor hours be minimized?
• Is staff already familiar with the process or will it require substantial staff training?
• Is the technology serviceable in the United States, or does it require parts from outside the country?
• Will reliance on third parties be minimized (e.g., for special maintenance, management /marketing the product(s), etc.)?</td><td>• Increase, decrease, or minimal change in:
o O&M labor hours
o O&M training
o Monitoring/ instrumentation
o Wait time for parts/support
o Specialized staff required and reliance on third parties</td><td>Qualitative</td><td>No Change</td></tr>
</table>

Guiding Principles/ Goals	Objectives	Evaluation Criteria					
		Criteria	Weight	Considerations	Metric(s)	Basis for Score[a]	
						Initial Evaluation[b]	Detailed Evaluation[c]
				• Will a third party manage or market the product?	o Complexity/difficulty of O&M activities		
	Maintain and improve resiliency of MWWTP and wastewater infrastructure such that interruptions of service are minimized and it can retain its essential function (i.e., protect life safety and convey wastewater flows to San Francisco Bay) under imminent changing conditions (e.g., seismic event, flooding) and gradual changing conditions (e.g., sea-level rise.	Resiliency	9%	• Does it maximize the ability to protect life safety and convey wastewater flows to SF Bay during the following events? o Seismic event (It is assumed new construction will have greater ability.) o Storm surge/flood event • Does it maximize the ability to maintain typical function under latest projected changes in sea/tide levels? • Does it enhance the ability to meet regulations and safety goals by providing resiliency?	• Increase, decrease, or minimal change in relative cost to protect life safety and convey wastewater flows to SF Bay • Increase, decrease, or minimal change in relative cost to maintain typical function	Qualitative	No Change
ENVIRONMENTAL							
Protect the environment, public health, and safety through reliable wastewater treatment that can proactively meet future regulations and minimize impacts to the local (San Francisco Bay) and global environment.	Continue to meet increasingly stringent water quality and environmental regulations and upgrade wastewater facilities to address future regulatory requirements.	Reliability and Flexibility to Meet Current and Potential Future Regulations	14%	• Can it reliably meet current regulations? • Does the alternative have flexibility to be modified to meet increasingly stringent regulations (including water quality, biosolids, and air regulations)?	• Minimal, moderate, or several alternate configurations/future technologies can be easily implemented over time	Qualitative	No Change
Promote resource recovery as a sustainable enterprise benefitting the region through responsible waste management and renewable energy generation.	Support sustainability goals by maximizing resource recovery and energy production, and minimizing energy consumption, greenhouse gas emissions, and use of non-renewable resources	Maximize Recoverable Resources	6%	• Does it maximize utilization of the R2 Program? • Does it support beneficial use of biosolids? • Does it support nutrient recovery? • Does it support water reuse?	• Increase, decrease, or minimal change in R2 Program • Increase, decrease, or minimal change in beneficial use of biosolids • Minimal, moderate, or high utilization of recoverable resources (treatment byproducts)	Qualitative (low, medium, high)	Qualitative score based on mass for all categories (R2, biosolids, nutrient recovery, water reuse)
		Minimize Treatment	10%	• Will it result in a change in GHG emissions?	• Increase, decrease, or minimal change in GHG emissions	Qualitative (low, medium, high)	No Change

Guiding Principles/ Goals	Objectives	Evaluation Criteria				Basis for Score[a]	
		Criteria	Weight	Considerations	Metric(s)	Initial Evaluation[b]	Detailed Evaluation[c]
		Process GHG Emissions					
		3a. Minimize energy purchases (electricity and natural gas)		• Will it minimize flaring of biogas? • Will it increase the biogas/energy generation potential? • Is this Master Plan alternative energy efficient?	• Low, medium, or high energy purchase	Quantitative score based on kWh or Btu purchased per year	No Change
		3b. Minimize N_2O emissions (under consideration)		• Will it decrease the N2O at the plant and the receiving water (San Francisco Bay)?	• Increase, decrease, or minimal change in N2O emissions both at the MWWTP and at San Francisco Bay	Quantitative score based on GHGs from N2O emissions per year	No Change
		Minimize Chemical Use	5%	• Does it minimize chemical addition for treatment?	• Increase, decrease, or minimal change in chemical usage	Qualitative	No Change
SOCIAL							
Maintain positive relationships with community groups and minimize adverse community impacts through improved aesthetics, noise abatement, reduced truck traffic, and odor controls.	Minimize adverse visual, noise, truck traffic, and odor impacts from the MWWTP operations to neighbors to the extent practicable.	Community Acceptability	9%	• Will the alternative introduce a source of odors, noise, and/or other emissions? • Will the alternative result in adverse visual impacts? • Will the alternative increase or decrease local truck traffic? • Will the alternative provide a community benefit (e.g., product the community can use)?	• Decrease, increase, or minimal change in negative community impacts: o Noise o Odor emissions o Number of structures negatively impacting views or visual aesthetics o Truck traffic • Decrease, increase, or minimal change in positive community impacts: o Community benefits	Qualitative	No Change
Maintain safe and engaging work environment at EBMUD facilities.	Prioritize worker safety and maintain an engaging work environment at EBMUD facilities.	Facility Safety	17%	• Does the alternative promote staff safety	• Increase, decrease, or minimal change in the safety of the facilities/ work environment	Qualitative	No Change
		Facility and Public Engagement	2%	• Does the MWWTP promote staff and public engagement (e.g., functional and aesthetic site layout, adequate space for staff collaboration and public visitors)?	• Increase, decrease, or minimal change in factors/ amenities promoting staff and public engagement	Qualitative	No Change

<table>
<tr><th rowspan="3">Guiding Principles/ Goals</th><th rowspan="3">Objectives</th><th colspan="6">Evaluation Criteria</th></tr>
<tr><th rowspan="2">Criteria</th><th rowspan="2">Weight</th><th rowspan="2">Considerations</th><th rowspan="2">Metric(s)</th><th colspan="2">Basis for Score[(a)]</th></tr>
<tr><th>Initial Evaluation[(b)]</th><th>Detailed Evaluation[(c)]</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>• Increase, decrease, or minimal change in potential for highly functional and aesthetic site layout/facilities</td><td></td><td></td></tr>
<tr><td colspan="8">ECONOMIC</td></tr>
<tr><td rowspan="4">Maintain fair and reasonable rates for customers by maximizing economic benefits through operating efficiencies and cost-effective alternatives.</td><td>Maintain fair and reasonable rates, including determining the role of resource recovery and beneficial use of treatment byproducts.</td><td rowspan="4">Life Cycle Cost</td><td rowspan="4">NA</td><td rowspan="4">• Does it minimize life cycle cost (capital and O&M cost) at Build-Out in 2020 U.S. dollars?</td><td rowspan="4">• Life cycle cost (capital and O&M cost) at Build-Out in 2020 U.S. dollars</td><td rowspan="4">Quantitative score scaled based on least life cycle cost at Build-Out</td><td rowspan="4">No Change</td></tr>
<tr><td>Maintain transparent and accurate cost accounting and financial reporting.</td></tr>
<tr><td>After meeting service area needs, utilize additional capacity for ratepayer benefit (i.e., to reduce ratepayer costs).</td></tr>
<tr><td>Maintain cost-effective, “no-regrets” investments in wastewater facilities (e.g., through asset management, system upgrades, efficient operations, land utilization, assimilation of new technologies, etc.).</td></tr>
</table>

a. Scoring to be assigned where 5 is the highest (best alignment with criteria) and 1 is the lowest (least alignment with criteria).
b. Initial Evaluation of alternatives to occur in Nutrient Reduction and Biosolids Workshop No. 2. 12 alternatives to be evaluated and 4 to be selected (2 nutrient removal alternatives and 2 biosolids alternatives).
c. Detailed Evaluation of alternatives to occur in Nutrient Reduction and Biosolids Workshop No. 3. 2 alternatives to be evaluated and 1 to be selected (1 nutrient removal and 1 biosolids).

APPENDIX H – GREENHOUSE GAS EMISSIONS CALCULATIONS

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This appendix summaries the greenhouse gas (GHG) emissions and offset calculations. Table H-1 summaries the factors used in the calculations. Table H-2 summarizes the inputs and GHG calculations.

Table H-1. Greenhouse gas factors and assumptions

Factor	Units	Value	Sources
Energy and Fuel Factors			
Electricity, CAMX - WECC California	Lb CO2e/MWh	499	US EPA, eGRID Summary Tables 2018; Table 1. Subregion Output Emission Rates
Electricity, CAMX - WECC California	kg CO2e/MWh	226	Calculated
Natural Gas	kg CO_2e/mmBTU	53.0600	EPA, 2018 Emissions Factors for GH Inventories Table 1 (last updated 3/9/20)
Diesel Fuel	kg CO_2e/gallon	10.2100	EPA, 2018 Emissions Factors for GH Inventories Table 2 (last updated 3/9/20)
Diesel Fuel efficiency	miles/gallon	12	Assumed
Chemical Factors			
Pure Caustic NaOH energy intensity	kWh/lb	1.0	provided via email by Sarah Deslauries.
Pure Caustic NaOH emission factor	kg CO2e/lb NaOH	0.226	Calculated
CO2 equivalents of Polymer manufacture	Mt CO2eq/Mt polymer	9.0	BEAM default value from Carnegie Mellon Green Design Inst. (http://www.eiolca.net/accessed March 2010)
Biogas Factors			
Percent biogas emitted when burned or flared	percent	1%	assumes inefficient process (0.3% if efficient); BEAM
Percent methane in Biogas	percent	60%	Assumed based on average methane content of biogas
Density of Methane at 35C	kg/m^3	0.63	BEAM
CO_2e to CH_4	ratio	21.00	BEAM
Biosolids Factors			
Biosolids Hauling Round Trip EMBUD to Land App	miles	220	updated based on data
Biosolids Hauling Round Trip EMBUD to Storage to Land App	miles	320	assumed based on information provided
Biosolids Hauling Weight	wt/load	20	Assumed based on average load allowed by DOT
Fertilizer Offsets and Sequestration			
Biosolids Carbon Sequestration	lbs CO_2e/lbs-dry biosolids	0.25	BEAM default value from Sally Brown' unpublished research
Total nitrogen	%-dry weight	0.05	BEAM default value for digested biosolids
Total phosphorus	%-dry weight	0.02	BEAM default value for digested biosolids
Credit for Nitrogen	kg CO2/kg N	4	Recycled Organics Unit, 2006 (BEAM)
Credit for Phosphorus	kg CO2/kg P	2	Recycled Organics Unit, 2006 - as per SLB, we will not go into nutrient availability indices; a kg of N or P is simply a kg of N or P (BEAM)
Common Conversion Factors			
Metric ton to lbs	1 Mt = 2204.62 lbs	2204.62	
kg to metric ton	1Mt = 1000 kg	1000.00	

Table H-2. Summary of Greenhouse Gas emissions and offset calculations

Parameter	Units	Alternatives								
Alternative Inputs										
Power Usage	kWh/yr	55,719,029	55,719,029	55,748,229	58,092,089	61,442,229	57,295,679	57,892,628	57,946,989	SWEET Output for 2050
Power Production	kWh/yr	99,215,760	99,215,760	99,215,760	99,215,760	99,215,760	99,215,760	99,215,760	99,215,760	SWEET Output for 2050
Net Power	kWh/yr	-43,496,731	-43,496,731	-43,467,531	-41,123,671	-37,773,531	-41,920,081	-41,323,132	-41,268,771	Calculated
Natural Gas Usage	million Btu/yr	0	0	0	162,491	228,175	0	0	1,091	SWEET Output for 2050
Methane (CH_4) and Nitrous Oxide (N_2O) Emissions from Biogas Combustion		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Engines	scf/yr	1,600,452,000	1,600,452,000	1,600,452,000	1,600,452,000	1,600,452,000	1,600,452,000	1,600,452,000	1,600,452,000	SWEET Output for 2050
Boiler	scf/yr	0	0	0	92,342,005	71,781,754	0	0	0	SWEET Output for 2050
Flare	scf/yr	71,781,754	71,781,754	71,781,754	0	0	71,781,754	71,781,754	71,781,754	SWEET Output for 2050
Bisolids handling										
Land Application	wet ton/yr	106,558	106,558	106,558	84,126	26,920	172,922	128,458	14,168	SWEET Output for 2050
Land Application	dry ton/yr	25,574	25,574	25,574	21,873	25,574	28,013	26,334	13,460	SWEET Output for 2050
Landfill	wet ton/yr	0	0	0	0	0	0	0	0	SWEET Output for 2050
Landfill	dry ton/yr	0	0	0	0	0	0	0	0	SWEET Output for 2050
Polymer Usage	lbs-polymer/yr	772,546	772,546	772,546	1,531,905	772,546	485,815	325,580	772,546	SWEET Output for 2050
45% Solution Caustic NaOH Usage	lbs-NaOH/yr	0	0	0	0	0	461,609	152,331	0	SWEET Output for 2050
Pure Solution Caustic NaOH Usage	lbs-NaOH/yr	0	0	0	0	0	207,724	68,549	0	Calculated

Parameter	Units	Alternatives								
GHG Emissions										
Purchased Power Usage	metric tons CO_2e/yr	0	0	0	0	0	0	0	0	
Natural Gas Usage	metric tons CO_2e/yr	0	0	0	8,622	12,107	0	0	58	
Methane (CH_4) and Nitrous Oxide (N_2O) Emissions from Biogas Combustion		n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Engines	metric tons CO_2e/yr	3,620	3,620	3,620	3,620	3,620	3,620	3,620	3,620	fugitive emissions from process, biogenic emissions from combustion not included/calculated
Boiler	metric tons CO_2e/yr	0	0	0	209	162	0	0	0	fugitive emissions from process, biogenic emissions from combustion not included/calculated
Flare	metric tons CO_2e/yr	162	162	162	0	0	162	162	162	fugitive emissions from process, biogenic emissions from combustion not included/calculated
Biosolids Hauling	metric tons CO_2e/yr	997	1,451	997	787	252	1,618	1,202	133	Assumed 4 mnths of offsite storage
Landfill	metric tons CO_2e/yr	0	0	0	0	0	0	0	0	see landfill disposal tab (assumes 0% gas recovered)
Polymer Usage	metric tons CO_2e/yr	3,154	3,154	3,154	6,254	3,154	1,983	1,329	3,154	
Pure Solution Caustic NaOH Usage	metric tons CO_2e/yr	0	0	0	0	0	47	16	0	
Nitrous Oxide (N_2O) Treatment Process Emissions at MWWTP and in SF Bay	metric tons CO_2e/yr	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	Per IPCC and EPA standards, includes N_2O emissions from nitrification and denitrification processes.

Parameter	Units	Alternatives								
GHG Offsets										
Avoided Purchased Power (Cogeneration)	metric tons CO_2e/yr	-9,839	-9,839	-9,833	-9,302	-8,545	-9,483	-9,348	-9,335	
Land Application - Carbon Sequestration	metric tons CO_2e/yr	-5,800	-5,800	-5,800	-4,961	-5,800	-6,353	-5,972	-3,053	
Land Application - Offsetting Synthetic Fertilizer N	metric tons CO_2e/yr	-4,640	-4,640	-4,640	-3,969	-4,640	-5,083	-4,778	-2,442	
Land Application - Offsetting Synthetic Fertilizer P	metric tons CO_2e/yr	-882	-882	-882	-754	-882	-966	-908	-464	
Totals										
Total Emissions	**metric tons CO_2e/yr**	7,934	8,387	7,934	19,492	19,295	7,431	6,330	7,127	
Total Offsets	**metric tons CO_2e/yr**	-21,161	-21,161	-21,154	-18,986	-19,866	-21,884	-21,006	-15,294	
Net Emissions	**metric tons CO_2e/yr**	-13,227	-12,774	-13,221	506	-571	-14,453	-14,676	-8,167	

APPENDIX I – NON-ECONOMIC EVALUATION SCORING

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Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [a]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Technical											
Efficient Land Use and Site Layout	Does it minimize the footprint required per mgd of influent? Does it leave space for future improvements, expansion, or upgrades? How well do future facilities integrate with existing facilities?	Acreage of treatment facilities (Qualitative: low, medium, high) Synergies in facility placement and logical flow (Qualitative: high, medium, low)	Score and Justification	5 Same footprint as existing	1 Would require high acreage for storage, truck traffic, parking and admin building	5 Minimal footprint (Screening only)	2 Relatively high acreage b/c predewatering building and storage is still needed (bunker type)	4 Low land requirements and storage in a silo so efficient use of land	3 More land than Alt 3; Storage in a tank to use land better - flexibility b/c product is a liquid. Also can go taller to minimize footprint.	3 Same land as Alt 4A.	4 Low land requirements and less product volume for storage than dryer. Product is bagged so less footprint.
Construct-ability	How easily can the future facilities be constructed? How easy will it be to continue operating the existing processes during construction?	Simplicity of construction phasing (Qualitative: simple, moderate, or complex)	Score and Justification	5 No construction within the facility process. All offsite	5 No construction within the facility process. All offsite	5 Minimal construction - only new screening is included.	3 Need to tie into process b/c this is pre-digestion. More to construct with pre-dewatering	4 Post-digestion with exception of screening. Post-digestion is easier to construct- minimal tie ins	4 Post-digestion with exception of screening. Post-digestion is easier to construct- minimal tie ins	4 Post-digestion with exception of screening. Post-digestion is easier to construct- minimal tie ins	4 Post-digestion with exception of screening. Post-digestion is easier to construct- minimal tie ins

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [a]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Technology Maturity/ Reliability	How many existing WWTPs have the proposed technology/approach? How large are they and how long have they been operating successfully? Will the treatment process be reliable and robust with respect to meeting current and future regulations under a variety of flow/load conditions? Does this alternative have flexibility to handle high peaking factors/wet weather flows?	Operating history (Qualitative: significant, moderate, minimal) based on: - Number of installations - Size of installations - Years of successful, reliable operation meeting similar regulations Effluent quality consistently meets potential effluent limits under variable flow/load conditions (Qualitative: high, medium, low consistency)	Score and Justification	5 N/A	5 N/A	5 NA	4 Most installations are in Europe - technology is high on S-curve but less operational experience in the US.	5 Established	4 10 operating installations in N. America - established technology.	4 10 operating installations in N. America - established technology.	2 Emerging technology - not as many operating facilities. No operating facilities at the size that EBMUD would need.

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [a]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Flexibility/ Ease of O&M	Will O&M labor hours be minimized? Is staff already familiar with the process or will it require substantial staff training? Is the technology serviceable in the United States, or does it require parts from outside the country? Will reliance on third parties be minimized (e.g., for special maintenance, management /marketing the product(s), etc.)? Will a third party manage or market the product?	O&M effort (Qualitative: low, medium, high) based on: - O&M labor hours - O&M training - Monitoring/ instrumentation - Wait time for parts/support - Specialized staff required and reliance on third parties - Complexity/ difficulty of O&M activities	**Score and Justification**	5	2	5	2	3	4	4	2
				Status Quo - O&M labor hours will be identical and staff if familiar with process.	Requires additional O&M for most of the year.		Steam system requires specialized O&M staff. More mechanical parts and unit processes	Higher safety precautions with production and storage of pellets	Lower pressure, low steam boilers ; minimal mechanical parts. Easy to pump post-treatment.	Lower pressure, low steam boilers ; minimal mechanical parts. Easy to pump post-treatment.	Thermal dryer upstream of pyrolysis reactor; somewhat unknown for pyrolysis reactor due to limited operating history. High temperature steam is required.

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [(a)]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Resiliency	Does it maximize the ability to protect life safety and convey wastewater flows to SF Bay during the following events? - Seismic event (It is assumed new construction will have greater ability.) - Storm surge/flood event Does it maximize the ability to maintain typical function under latest projected changes in sea/tide levels? Does it enhance the ability to meet regulations and safety goals by providing resiliency?	Relative change in cost to protect life safety and convey wastewater flows to SF Bay (Qualitative: decrease, minimal change, increase) Relative change in cost to maintain typical function (Qualitative: decrease, minimal change, increase)	Score and Justification	3 Lower score due to need to retrofit second stage digesters and dewatering	3 Lower score due to need to retrofit second stage digesters and dewatering	3 Lower score due to need to retrofit second stage digesters and dewatering	3 High temperature and high pressure increase safety concerns; 3-second stage digesters do not need seismic rehab	3 Lower score due to need to retrofit second stage digesters and dewatering	3 Lower score due to need to retrofit second stage digesters and dewatering	3 Lower score due to need to retrofit second stage digesters and dewatering	3 Lower score due to need to retrofit second stage digesters and dewatering
Environmental											
Flexibility to Meet Current/ Future Regulations	Can it reliably meet current regulations? Does the alternative have flexibility to be modified to meet increasingly stringent regulations (including water quality, biosolids, and air regulations)?	Flexibility to easily implement alternate configurations/ future technologies over time (Qualitative: high, medium, low)	Score and Justification	2 Inflexible to meeting new regulations	3 Should be able to permit; however, have heard that it may take a significant amount of time.	3 Relies on marketing ability of outside contractors with composting most likely to be shaped by ag markets.	2 Soil blending market uncertain and requires marketability by EBMUD to develop a market for this product.	5 Opens urban and suburban markets; significant volume reductions, meaning tonnages are more manageable in the local region. PFAS levels likely to be lower than other technologies (evaporated with water)	2 Only going to ag and would need development to change market. No destruction of PFAS known at this time.	2 Only going to ag and would need development to change market. No destruction of PFAS known at this time.	4 Opens urban and suburban markets; significant volume reductions, meaning tonnages are more manageable in the local region. Potential for destruction of PFAS.

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [a]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Maximize Recoverable Resources	Does it maximize utilization of the R2 Program? Does it support beneficial use of biosolids? Does it support nutrient recovery? Does it support water reuse?	Change in R2 Program (Qualitative: increase, minimal change, decrease) Beneficial use of biosolids (Qualitative: high, medium, low) Utilization of recoverable resources (treatment byproducts) (Qualitative: high, medium, low)	Score and Justification	2	3	3	4	3	2	2	3
				Does not address nutrient recovery or improve process/capacity	Not realizing any additional benefits, not directly controlling the direct benefits.	Not realizing any additional benefits, not directly controlling the direct benefits.	Potential biogas increase would not be significant. The end use product may not open new markets. THP causes an increase in ammonia and TN to liquid stream, which requires additional treatment. If AMR is used on side stream, more ammonia can be recovered and sold as product.	Increased energy (natural gas) usage, but opens additional end use markets.	Unless using lystemize configuration, does not improve biogas production. The resulting end product is meant for agricultural markets. Less liquid returned as centrate so less ammonia to recover in AMR side stream treatment.	Unless using lystemize configuration, does not improve biogas production. The resulting end product is meant for agricultural markets. Less liquid returned as centrate so less ammonia to recover in AMR side stream treatment.	Increased energy (natural gas) usage, but opens additional end use markets.

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Alt 0 Status Quo	Alt 0A Modified Status Quo	Alt 1 Merchant Facilities	Alt 2 THP	Alt 3 Thermal Drying	Alt 4A/B Lystek 100% w/ Storage	Alt 4C Seasonal Lystek w/o Storage	Alt 5 Pyrolysis
				Unweighted Scores [a]							
Minimize Treatment Process GHG Emissions	Will it result in a change in GHG emissions?	GHG emissions (Qualitative: low, medium, high)	Score and Justification	4	3	4	1	3	5	5	2
a. Minimize energy purchases (electricity and natural gas)	Will it minimize flaring of biogas? Will it increase the biogas/energy generation potential? Is this Master Plan alternative energy efficient?	Energy purchase (Quantitative: metric tons carbon dioxide equivalent per year based on kWh or Btu purchased per year)	Justification	No change in GHG; Matches Alt 0A. Potentially less GHG emissions due to less trucking	Analysis assumes all biogas is utilized in the turbine and engines. Additional GHG were created due to longer haul distances	Analysis assumes all biogas is utilized in the turbine and engines.	Analysis assumes all biogas is utilized in the turbine and engines.	Analysis assumes all biogas is utilized in the turbine and engines.	Analysis assumes all biogas is utilized in the turbine and engines.	Analysis assumes all biogas is utilized in the turbine and engines.	Analysis assumes all biogas is utilized in the turbine and engines. Syngas is utilized for process heating of pyrolysis unit.
b. Minimize nitrous oxide (N2O) emissions (under consider-ation)	Will it decrease the N2O at the plant and the receiving water (San Francisco Bay)?	GHGs from N2O emissions both at the MWWTP and at San Francisco Bay (Quantitative: metric tons carbon dioxide equivalent per year based on N2O emissions)	Justification								
Minimize Chemical Use	Does it minimize chemical addition for treatment?	Chemical usage (Qualitative: low, medium, high)	Score and Justification	5	5	5	2	5	3	3	5
				No change in chemical usage	No change in chemical usage	No change in chemical usage	Requires additional polymer and chemicals to treat dilution water	No change in chemical usage	Some additional chemicals (lime)	Some additional chemicals (lime)	No change in chemical usage

Appendix I. Alternative Scoring for Non-Economic Evaluation Criteria

Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Unweighted Scores [a]							
				Alt 0	Alt 0A	Alt 1	Alt 2	Alt 3	Alt 4A/B	Alt 4C	Alt 5
				Status Quo	Modified Status Quo	Merchant Facilities	THP	Thermal Drying	Lystek 100% w/ Storage	Seasonal Lystek w/o Storage	Pyrolysis
Social											
Community Acceptability	Will the alternative introduce a source of odors, noise, and/or other emissions? Will the alternative result in adverse visual impacts? Will the alternative increase or decrease local truck traffic? Will the alternative provide a community benefit (e.g., product the community can use)?	Change in negative community impacts (Qualitative: decrease, minimal change, increase) based on: - Noise - Odor emissions - Number of structures negatively impacting views or visual aesthetics - Truck traffic Change in positive community impacts (Qualitative: decrease, minimal change, increase) based on: - Community benefits	Score and Justification	3 No Change	2 Introduces a new source for odors. The storage cake odors can be minimized with odor control; however, odors will be present when loading and offloading.	3 No change	3 No significant change	4 Reduced truck traffic due to reduced solids volume, and storage volume so less foul air for odor control	2 Increased trucked traffic; no effect on odors at the plant	3 Increased trucked traffic but less annual impact because less goes to Lystek over the year; no effect on odors at the plant	4 Reduced truck traffic due to reduced solids volume
Facility Safety	Does the alternative promote staff safety	Change in the safety of the facilities/ work environment (Qualitative: increase, minimal change, or decrease)	Score and Justification	3 No Change	3 No change	3 No change	2 Requires special trained operators for high steam boilers	1 Increased risk of fire, relative to current operation	2 No change	2 No change	1 Unknown risk with high temperature system

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Criteria	Considerations	Metrics (Qualitative/ Quantitative)		Alt 0 Status Quo	Alt 0A Modified Status Quo	Alt 1 Merchant Facilities	Alt 2 THP	Alt 3 Thermal Drying	Alt 4A/B Lystek 100% w/ Storage	Alt 4C Seasonal Lystek w/o Storage	Alt 5 Pyrolysis
				Unweighted Scores [a]							
Facility and Public Engagement	Does the MWWTP promote staff and public engagement (e.g., functional and aesthetic site layout, adequate space for staff collaboration and public visitors)?	Change in factors/ amenities promoting staff and public engagement (Qualitative: increase, minimal change, decrease) Change in potential for highly functional and aesthetic site layout/facilities (Qualitative: increase, minimal change, decrease)	Score and Justification	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator	3 Non-differentiator
		Total									
		Total Unweighted Score		**45**	**38**	**47**	**31**	**43**	**37**	**38**	**37**

Notes:
a) Score assigned on scale of 1 - 5.
1 = alternative is **LEAST** aligned with the criteria
5 = alternative is **MOST** aligned with the criteria