Technical Memorandum

Sand Island WWTP
Evaluation of Sludge Processing Alternatives

Oahu, Hawaii

Final

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ACRONYMS/ABBREVIATIONS

BAF	Biological aerated filter
Btu	British thermal unit
CCH	City and County of Honolulu
CFU	Colony forming units
CHP	Combined heat and power
EA	Environmental Assessment
ENV	Department of Environmental Services
EPA	United States Environmental Protection Agency
F	Fahrenheit
IPS	Influent Pump Station
LCCA	Life-cycle cost analysis
mgd	million gallons per day
MPN	Most probable number
MSW	Municipal solid waste
NPDES	National Pollutant Discharge Elimination System
NPV	Net present value
PSRP	Process to significantly reduce pathogens
PFRP	Process to further reduce pathogens
Sand Island Fac Plan	Sand Island Wastewater Facilities Plan
SIWWTP	Sand Island Wastewater Treatment Plant
SMA	Special Management Area
UV	Ultraviolet
WWPS	Wastewater Pump Station
WWTP	Wastewater Treatment Plant
ZOM	Zone of Mixing

EXECUTIVE SUMMARY

The City and County of Honolulu (CCH) Department of Environmental Services (ENV) is in the process of developing the Sand Island Wastewater Facilities Plan (Sand Island Fac Plan) which covers the Sand Island sewer basin. The study area for the Sand Island Fac Plan consists of the Sand Island Wastewater Treatment Plant (SIWWTP) and its wastewater service area serving the eastern half of Oahu. The SIWWTP sewer basin serves a population of over 700,000 and provides preliminary and primary treatment to all flows at present. Currently, SIWWTP treats approximately 60 million gallons per day (mgd) of wastewater from the sewer basin.

AECOM has prepared this preliminary engineering study report for various alternatives to retrofit the existing Sand Island Biosolids Processing System (operated by Synagro). CCH requested a review to evaluate whether alternative options that incorporate incinerating residuals at H-Power are viable and cost effective compared to the construction of a second digester in accordance with the provisions of the existing Synagro contract. An additional driver and goal for CCH is to eliminate landfilling waste materials other than ash in the near future.

EVALUATED OPTIONS

A summary of the options evaluated in this report along with capital and 20 year present worth life cycle Costs (LCC) cost are listed in **Table ES-1** and defined as follows:

- Baseline - Build new digester and continue to operate existing dryer. A sub option incorporating combined heat and power (CHP) was also evaluated.
- Option 1 - Dewater the excess raw undigested primary sludge and transfer the cake material to H-Power for incineration.
- Option 2 - Dewater blended digested and undigested primary sludge and transfer the cake material to H-Power for incineration. A sub option incorporating CHP was also evaluated.
- Option 3 - Dewater and chemically treat undigested sludge and transfer cake to H-Power for incineration
- Option 4 - Dry blended digested and undigested primary sludge using the existing dryer and transfer the dry material to H-Power for incineration.
- Option 5 - Dry blended digested and undigested primary sludge replacing the existing dryer and transfer the dry material to H-Power for incineration. A sub option incorporating CHP was also evaluated.
- Option 6 - Dry undigested sludge using a new dryer and transport the dry material to H-Power for incineration.
- Option 7 - Build a second digester and replace existing dryer with one that operates utilizing waste heat from cogeneration

The above options consider inclusion of CHP where appropriate. CHP is currently intended for future implementation at WWTPs as part of island-wide planning.

A summary and comparison of some of the non-economic factors for each Option is shown in **Table ES-2**. There are non-quantifiable aspects that need to be considered in the decision but

since they are policy-related, CCH should carefully consider the attached table in order to incorporate aspects such as reliability and risk in addition to cost and timing in its decision-making process.

It should be noted that Options evaluated and life cycle costs presented in this report do not account for:

- Increase in solids production due to planned secondary treatment beyond 2035
- Potential revenue from H-Power from energy produced by the sludge used as fuel, as the specific details of this are to be determined based on agreement with the H-Power operator.
- Options for incineration at SIWWTP

Preliminary implementation milestones for the Baseline following a notice to proceed (NTP) are:

- Complete Design: 6 Months from NTP
- Obtain EA/SMA/Permits: 8 Months from NTP
- Procurement and Award: 4 Months from Permit Approval
- Construction Complete: 30 Months from Award
- Total Estimated Duration: 42 Months (3.5 Years)

The engineering, permitting, procurement and equipment supply for all Options would have a similar duration to the Baseline. The construction of the digester is somewhat of a specialty and may take slightly longer than installation of equipment such as an alternate dryer or centrifuge. However, the above timeline should be used for planning purposes regarding any of the evaluated options.

It should be noted that the time needed for the front end of the procurement process, prior to the NTP, may vary considerably depending on whether an existing contract is amended or a new procurement process is started. The difference in the two processes varies but can potentially be significant, perhaps up to a full year difference in the time required.

CONCLUSION

The 20 year life cycle cost estimates for the Baseline Options and Options 1, 2b, 4, 5, 5b and 7 are all within approximately 10% of one another. With the accuracy of cost estimation available for this level of planning purposes it is possible that the actual ranking may vary with detailed planning, design, construction and implementation. There are specific limitations that were identified for some of these options:

- Options 2b - The H-Power operator has indicated to CCH that undigested sludge product (Options 2b) would not be an acceptable product other than on a short term emergency basis.
- Option 4 – The existing dryer manufacturer highly discourages the drying of blended sludge (Option 4) and may not warranty operation of their equipment in such a manner.
- Option 5 – The 20 year life cycle cost is similar to that for implementing the Baseline Option with CHP. However, the lack of a second digester reduces the overall process reliability when compared to the Baseline Options and would require disposal of large amounts of undigested cake during maintenance or repair of the existing digester.

Additionally, the lower quality blend of digested and undigested sludge may limit marketability as a fertilizer product.

- Option 7 – The overall cost and process reliability is similar to that of the Baseline Option. However, the dry product will not have the same uniformity characteristics as the existing pellets and may reduce marketability as a fertilizer product.

Based on the above, the Baseline Option and Option 7 have the highest level of process reliability, while meeting the requirements of the dryer manufacturer (Andritz) and acceptability by the H-Power operator (Covanta). Options 1 or 2 may be accepted by H-Power on emergency or short term interim basis dependent on quality and quantity of material.

Table ES-1: Options Summary

Option	Digestion	Dewatering	Chemical Treatment	Drying	Biogas Use	Offsite Incineration	Fertilizer Product	Capital Costs[1]	20 Year LCC[2]
Baseline	Additional digester	All as digested	None	Existing direct dryer for all (digested)	Digester heating and drying, excess flared	None	Continue existing pellets w/ digested	$25.7 MM	$94.1 MM
Baseline (With CHP)[3]	Additional digester	All as digested	None	Existing direct dryer for all (digested)	Digester heating and drying, excess to CHP cogen	None	Continue existing pellets w/ digested	$34.2 MM	$93.8 MM
Option 1	Existing digester only	Digested and undigested separately	Undigested cake portion	Existing direct dryer for only digested portion	Digester heating and drying, excess flared	Dewatered cake undigested	Continue existing pellets w/ digested	$8.7 MM	$99.6 MM
Option 2	Existing digester only	Digested and undigested separately	Undigested cake portion	None	Digester heating, excess flared	Dewatered cake blended	None	$8.7 MM	$111.9 MM
Option 2 b (With CHP)	Existing digester only	Digested and undigested separately	Undigested cake portion	None	Digester heating and CHP cogen	Dewatered cake blended	None	$22.1 MM	$99.0 MM
Option 3	No digestion	All as undigested	All as undigested cake	None	None	Dewatered cake undigested	None	$11.2 MM	$184.7 MM
Option 4	Existing digester only	Digested and undigested separately	Potential backup	Existing direct dryer for all (blended)	Digester heating and drying, excess flared	Dried pellets blended	Lower quality pellets w/ blended	$9.0 MM	$95.4 MM
Option 5	Existing digester only	Digested and undigested separately	Potential backup	New indirect dryer for all (blended)	Digester heating and drying, excess flared	Dried granular blended	Lower quality granular solids w/ blended sludge	$17.0 MM	$85.7 MM
Option 5b (With CHP)	Existing digester only	Digested and undigested separately	Potential backup	New indirect dryer for all (blended)	CHP cogen w/ waste heat for digester heating and drying	Dried granular blended	Lower quality granular solids w/ blended sludge	$30.4 MM	$102.2 MM
Option 6	No digestion	All as undigested	Potential backup	New indirect dryer for all (undigested)	None	Dried granular undigested	Lower quality granular solids w/ undigested primary sludge	$22.4 MM	$144.7 MM
Option 7 (Incl. CHP)	Additional digester	All as digested	None	New indirect dryer for all (digested)	CHP cogen w/ waste heat for digester heating and drying	None	Less uniform product than direct dryer w/ digested	$53.0 MM	$97.3 MM

1. The carrying costs associated with construction of the original digester and bioconversion facility are not included as part of the Capital Costs or LCC. Issues such as remaining bond repayment and remaining contractual arrangements are not included or accounted for as part of these costs and may alter final rankings if and when considered. Capital costs are based on February, 2011 costs $ENR_{20\ Cities}$ Index = 9,000.
2. Operating costs of the solids processing facilities are based on existing operations as well as typical operating costs associated with the representative processing technologies and may vary based on contractual conditions with third party operators. Section 5.1 provides additional information regarding third party operating costs.
3. CHP: Combined Heat and Power cogeneration using digester biogas

Table ES-2: Non-Economic Factors

Option	Process Risk	Back-up Processes	Operational Complexity	Comparison to Typical Industry Practice	Dryer Manufacturer Acceptability	H-Power [1] Acceptability
Baseline	Low - well proven	Second Digester and Chemical Treatment	Medium	Commonly used	Accepted by existing dryer manufacturer	Acceptable as dry pellets or digested cake
Baseline (with CHP)	Low - well proven	Second Digester and Chemical Treatment	Medium	Commonly used	Accepted by existing dryer manufacturer	Acceptable as dry pellets or digested cake
Option 1	Low - well proven	Chemical Treatment	Medium to High	Both processes commonly used	Accepted by existing dryer manufacturer	Not acceptable as undigested cake
Option 2	Low - well proven	Chemical Treatment	Low to Medium	Both processes commonly used	No Drying	Not acceptable as undigested cake
Option 2b (with CHP)	Low - well proven	Chemical Treatment	Medium	Both processes commonly used	No Drying	Not acceptable as undigested cake
Option 3	Low - well proven	Chemical Treatment	Low	Commonly used	No Drying	Not acceptable as undigested cake
Option 4	High - against vendor recommendation	Chemical Treatment	Medium	Uncommon	Discouraged by existing dryer manufacturer	Acceptable as dry pellets or digested cake
Option 5	Medium - limited successful applications	Chemical Treatment	Medium	Uncommon	Accepted by multiple manufacturers	Acceptable as dry pellets or digested cake
Option 5b (with CHP)	Medium - limited successful applications	Chemical Treatment	Medium	Uncommon	Accepted by multiple manufacturers	Acceptable as dry pellets or digested cake
Option 6	High - No reference sites	Chemical Treatment and Dryer	Medium	Uncommon	Discouraged by several manufacturers	Acceptable as dry pellets or digested cake
Option 7 (with CHP)	Low - well proven	Second Digester and Chemical Treatment	Medium	Commonly used	Accepted by multiple manufacturers	Acceptable as dry pellets or digested cake

[1] H-Power would consider the acceptance of undigested cake on an emergency short term basis only.

RECOMMENDATION

There are several key issues that are driving the future for sludge processing and disposal locally:

- The changing demographics of the island land use away from agricultural activities toward residential and tourism could eventually limit the future market of land application for soil amendment and fertilizer purposes. The currently available and planned facilities that CCH intends to use for creation of fertilizer and compost product should be adequate to meet future market demands. The current pelletized fertilizer product produced by Synagro is currently supplied to users at no charge and the market demand for such product does not appear to have a strong future growth opportunity. The demographic of residential and tourism typically prefer other soil amendment products that do not use wastewater biosolids and often require significant engagement to prove that it has equivalent aspects to other market products.
- There is a relatively high cost of both fossil fuels and electrical power locally and a national trend for energy costs to continue to grow at a greater pace than inflation. Due to the rising cost of power and recent technology developments, the implementation of waste to energy and energy reduction improvements at wastewater and solids handling facilities is growing rapidly. These technologies typically consist of combined heat and power cogeneration using combustible biogas gas from anaerobic digesters as well as thermal oxidation of solids, which also greatly reduces the amount of waste material for disposal.
- Due to the limitation of available land there is a strong desire locally to limit or eliminate the amount of material that is required for disposal at a landfill. A goal for CCH is the elimination of landfilling of materials other than ash in the near future. The ongoing operation and expansion of the H-Power waste to energy facility plays a key role in this by greatly reducing the amount of material that is land filled while generating electricity from the municipal solid waste it receives.
- There are existing and established sludge processing assets in place at the three largest WWTPs. Many of these assets are relatively new and provide a consistent and reliable treatment process. Consideration of the potential operational benefits and capital investment already in place will be part of any future planning considerations.

Based on these key issues and available opportunity it is recommended that CCH pursue a long term strategy for the processing and disposal of sludge that focuses on cost effective recovery of energy and minimization of sludge solids through generation of an ash product by thermal oxidation. Additionally, CCH should retain the ability to have multiple processing and outlet sources available in the future to ensure continued and reliable service in the event of the unforeseen. Any changes to in plant processing or end use/disposal should be focused on establishing an overall level of risk and reliability that is equal to or better than current operations.

Available industry established technologies and strategies that either recover energy and/or reduce waste include:

- Anaerobic digestion reduces the volatile solids portion of sludge and creates a combustible biogas. The biogas can be used to generate both heat energy for use in treatment processes and electrical energy that can be using in the plant or returned to

the power grid. The digested end product is reduced in mass but would require subsequent thermal oxidation to convert to an ash product.

- Digested, undigested or blended sludge can be dewatered to create a cake product with approximately +/-30 percent solids concentration and thermally oxidized either onsite or off site. This material would burn autogenously (energy to remove water equals energy recovery from solids) generating no additional energy other than what is required to reduce the material to ash. It should be noted that digestion reduces the thermal energy available and would require a dryer cake product to burn autogenously, however, it reduces the incinerator mass throughput so the equipment sizing can be reduced.
- Digested, undigested or blended sludge can be dewatered and then dried to create a solid product with approximately +90 percent solids concentration and thermally oxidized either onsite or off site. This incinerated material has a high thermal value and may be capable of generating both heat and electrical energy while reducing the material to ash. As with incineration of cake material, digestion reduces the thermal energy available. Additionally there is heat energy required for drying of the material from the +/-30 percent solids to the +90 percent solids that would need to be taken into consideration of net energy benefit.

This strategy of waste minimization and energy recovery is aligned with that for municipal solids waste and there may be opportunities for pursuit of solutions that are mutually beneficial to both. The H-power facility is one potential outlet opportunity and should be fully pursued and developed along with other available outlets. H-Power is an operating and permitted facility that is currently planned to have the capability to receive 90 tons per day of +/-30 percent solids sludge cake material. It is unknown if or how much +90 percent dry sludge material H-Power could receive but this would represent a significant opportunity for energy recovery and waste reduction. It is recommended that is issue be fully investigated prior to making any long term decisions regarding sludge handling operations at any of the WWTPs.

CCH is currently engaged in an Island-wide Biosolids Master Plan, which will outline future needs and solutions for all nine CCH WWTPs in an integrated manner. Maintaining a diverse sludge management portfolio that allows for multiple disposal options such as land application, thermal processing (such as H-Power), or landfill disposition will provide the greatest flexibility to deal with market fluctuations and equipment outages.

With regards the current sludge processing facilities at SIWWTP the determination of modifications to the existing operation should be based on the final determination of the type and amount of material that can be received at H-Power. Additional considerations include the determination of cost effectiveness related to digestion and beneficial use of biogas to either generate electricity and/or provide thermal energy for drying and process operations. When comparing capital costs, consideration should be given to providing adequate redundant process equipment and/or back-up processes. If a second digester is not installed then a sufficient number of centrifuges and chemical treatment system should be installed sufficient to dewater and handle the undigested sludge flow. Additionally it should be ensured that a disposal outlet is capable of receiving undigested, chemically treated sludge in the quantity anticipated if the existing digester is out of service.

Based on the key aspects discussed, the life cycle cost comparison and keeping potential risk at or below current conditions it is recommended that a second digester be pursued that can maintain process reliability with a range of outlet opportunities. Furthermore the options available for incineration of cake and/or dried sludge at H-Power should be further evaluated and developed to provide opportunities for SIWWTP as well as the other eight CCH WWTPs.

Final determination of a long term outlet for the digested sludge from SIWWTP should be part of the Island-wide Biosolids Master Plan, which will consider the opportunities as H-Power and other potential outlets.