DEVELOPING A SUSTAINABLE BIOSOLIDS MANAGEMENT SOLUTION FOR FOURTEEN FACILITIES

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Abstract

North Texas Municipal Water District (NTMWD) developed a Biosolids Master Plan to evaluate potential sustainable biosolids management improvements. This paper describes that evaluation, the planning process utilized, and results. The methodology for evaluation includes multi-attribute utility analysis including both financial and non-financial criteria.

This paper summarizes results from the Biosolids Master Plan, which evaluated solids handling approaches for all of the NTMWD wastewater treatment plants. The District's service area is located northeast of Dallas, TX, and has a current drinking water service population of approximately 1.6 million, of which the majority also receives wastewater service. NTMWD currently treats an average of 378.5 megaliters per day (ML/d) (100 million gallons per day (mgd)) of wastewater, with anticipated future average flows of 700 ML/d (185 mgd) in 2040. The District currently operates fourteen (14) wastewater treatment plants that each serve populations ranging from less than 1,000 to 400,000. Wastewater residuals from the facilities are currently thickened, dewatered, and landfilled, with most of the residuals placed in a landfill also owned by the District.

Multiple residuals management technologies were evaluated, with considerations for capital cost, operation and maintenance cost, and non-monetary factors such as odors, noise, permitting, and beneficial reuse. In addition, the District-owned landfill enabled consideration of options that utilize landfill biogas to offset the cost to purchase natural gas for energy intensive processes.

An evaluation of each WWTP facility and a projection of anticipated loads revealed that approximately eighty percent of all residuals are generated by three of the fourteen WWTPs, so most capital improvement options were focused on the three largest WWTPs. Interplant material transfers were considered as well to centralize residuals processing taking into account the district geography, existing sewer lines connecting some plants, and the proximity of adjacent WWTPs. For each facility a mass balance approach was taken to determine design parameters, and costs associated with each alternative were developed.

The combination of non-financial scores resulted in a cumulative "Benefit" score for each biosolids option. The relative contribution of each criterion will be presented. Without consideration of the project cost, Thermal Drying received the highest total benefit score, followed by Thermal Hydrolyis and Composting, with Landfilling receiving the lowest non-monetary score.

These non-monetary scores were combined with the estimated net present value for each alternative to develop a relative benefit-cost score for each option. The rankings revealed that

digestion-based approaches would be the most favorable long term biosolids management option for the District.
The paper will provide valuable insight into trends in the residuals industry including the drivers for change to more sustainable systems, and technological advances enabling facilities to adapt more efficiently.

Keywords

Residuals, Biosolids, Management, Planning, Benefit-Cost, Alternatives Analysis

Introduction

North Texas Municipal Water District (NTMWD or District) currently operates four (4) wastewater treatment plants (WWTPs) in the Regional Wastewater System, and an additional ten (10) treatment plants are included in the District Sewer System. From the treatment process, NTMWD currently produces approximately 71 dry metric tonnes per day (Dt/d) (78 dry U.S. tons per day (DT/d)) of wastewater residuals with a projected amount of 127 Dt/d (140 DT/d) in 2040. The current practice for disposal of wastewater residuals by most District facilities is to dewater the solids, add lime at some plants, and ultimately dispose of the residuals in a landfill. NTMWD currently sends 41 truck loads per day of wastewater residuals to the landfill with an average annual tipping fee of $1.8 million dollars per year for disposal of wastewater residuals. With continued landfill disposal, 2040 projections estimate NTMWD would send 51 truck loads per day and spend $11.3 million per year. The expected increase in landfill cost will be driven by a large anticipated increase in landfill tipping fees within the next five years. Landfill fees paid by NTMWD for wastewater solids are currently subsidized to below market value, and NTMWD expects to soon pay a rate consistent with the true market value.

A majority of the biosolids produced by NTMWD WWTPs are disposed at the 121 Regional Disposal Facility (RDF), owned and operated by NTMWD; however, biosolids are also transported to two other landfills for disposal. This process of dewatering and disposing of unstabilized wastewater residuals in a landfill has historically been an economical biosolids management method.

Since NTMWD first became involved in wastewater treatment in 1972, many factors associated with the treatment and disposal of wastewater residuals have changed significantly. For example, alternate methods of handling biosolids have been developed, practiced, and refined. The price of fuel used for the generation of electricity and transportation has increased dramatically. Additionally, processes have been developed that result in economically viable alternatives for the utilization of biosolids as a reusable product. Biosolids are now recognized as being a good source of nutrients for fertilizer and organic content for soil amendment as well as having a high energy content equaling that of coal (up to 23,000 kilojoules per dry kilogram (10,000 British thermal units per dry pound)).

Because of the future cost of wastewater residuals management, the changing fuels market, and changes in wastewater residuals treatment processes, NTMWD initiated a Biosolids Master Plan project in 2012. The plan evaluated the various methods of handling, treating, disposing, and beneficially reusing biosolids generated at NTMWD WWTPs, with particular focus on deriving energy from wastewater residuals via anaerobic digestion (AD) in order to offset operating costs and mitigate the risk of price variability of conventional power and transportation fuel. In addition, a higher quality (US EPA Class A) biosolids end product is desired since land application of Class B biosolids in Texas is facing greater scrutiny by the public.

Alternatives Evaluation Approach

A series of biosolids handling alternatives evaluations were performed that progressively refined the optimal biosolids handling approach for NTMWD. Many viable options exist for the beneficial use of biosolids. The industry is moving toward leveraging the energy and nutrient value within the biosolids for energy production to offset plant operating costs and beneficial use of the material as a fertilizer or soil amendment. Many facilities in Europe and North America are able to achieve energy neutrality; that is, they produce as much energy as the overall treatment process consumes. The alternatives evaluation began with a wide range of alternatives for consideration, and then the alternatives were narrowed for a more detailed evaluation of both the regional and medium-sized facilities operated by the District.

Given the number of alternatives and the complexities of each, a robust process for decision-making was used. Historically, utilities have used primarily capital cost analysis, and sometimes life-cycle cost analysis, to evaluate options. Utilities have found, however, that especially for long-term asset management and sustainability, economic criteria alone do not provide optimal decisions. Other qualitative factors such as odors and permitting must also be included in the decision process.

For the NTMWD Biosolids Master Plan, the analysis combined non-monetary benefit criteria with monetary criteria to provide for more robust decision-making. The results are presented in the form of a benefit-cost analysis. [1]

Initial Alternatives Evaluation

The initial alternatives evaluation considered the following technology alternatives:

- Unclassified Solids[2]:
- Landfill Disposal – The current disposal method in use by the District
- Landfill Biogas-fueled SlurryCarb™ Thermal Hydrolysis Process (THP) to Landfill Disposal[3]
- Class B Biosolids[4]:
- AD with Biogas-fueled Combined Heat and Power (CHP)
- Class A Biosolids[5]:
- Landfill Biogas-fueled SlurryCarb™ THP to Class A
- Composting
- Landfill Biogas-fueled Thermal Drying
- Lime Stabilization
- Thermal Hydrolysis with Biogas-fueled CHP
- Temperature-Phased Anaerobic Digestion (TPAD) with Biogas-fueled CHP

These alternatives were considered for the North Plants (Wilson Creek with solids received from Rowlett Creek RWWTP) and the South Plants (South Mesquite with solids transferred from Bear Creek, Buffalo Creek, and Crandall WWTPs)[6].

Tables 1 and 2 provide a summary of the financial evaluations for the North and South Plants. Note that for both facilities, the three AD alternatives rise to the top and are within 20 percent of the net present value (NPV) of the lowest cost solution.

Table 1: North Plants Financial Summary

Alternative	Total NPV	NPV Cost Rank	NPV Cost Ratio
TPAD	$70.1M	1	1.0
Thermal Hydrolysis	$77.4M	2	1.1
AD	$79.5M	3	1.1
Landfill	$96.6M	4	1.4
Compost	$103.4M	5	1.5
Thermal Dry	$104.5M	6	1.5
Lime Stabilization	$107.9M	7	1.5
SlurryCarb to Class A	$147.3M	8	2.1
SlurryCarb to landfill	$141.6M	9	2.0

Note:
M = million

Table 2: South Plants Financial Summary

Alternative	Total NPV	NPV Cost Rank	NPV Cost Ratio
TPAD	$36.0M	1	1.0
AD with CHP	$39.0M	2	1.1
Thermal Hydrolysis	$41.5M	3	1.2
Compost	$49.4M	4	1.4
Landfill	$63.2M	5	1.8
Lime Stabilization	$76.3M	6	2.1

Note:
M = million

The benefit criteria and criteria weighting were established in a structured workshop with District staff as depicted in Figure 1.

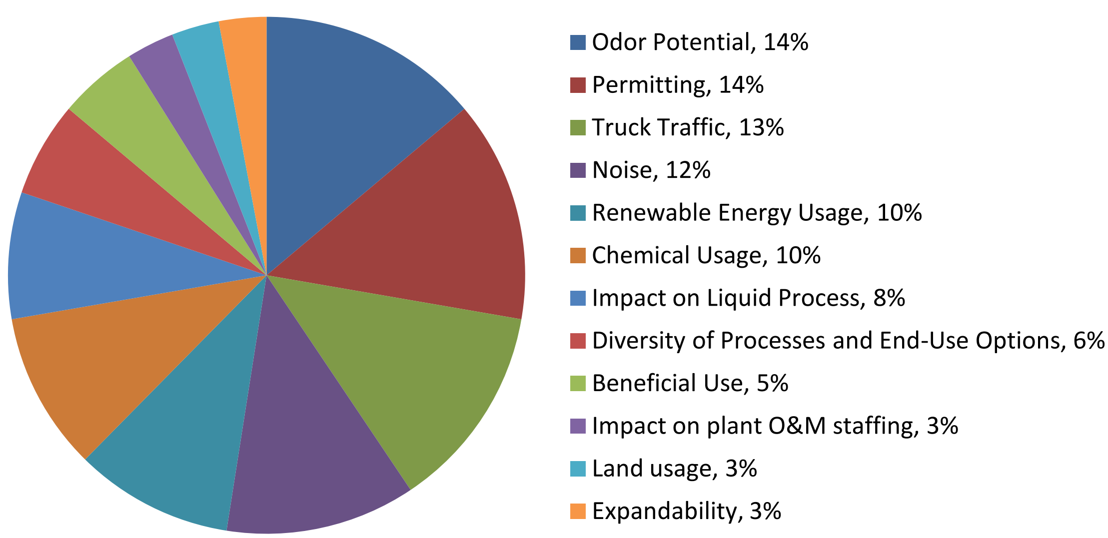

Figure 1: Non-Monetary Benefit Criteria and Weights

Figure 2 provides the resulting benefit-cost scores[7] for the South Plants, and a similar figure was developed for the North Plants. Note the three AD alternatives received the highest benefit-cost scores.

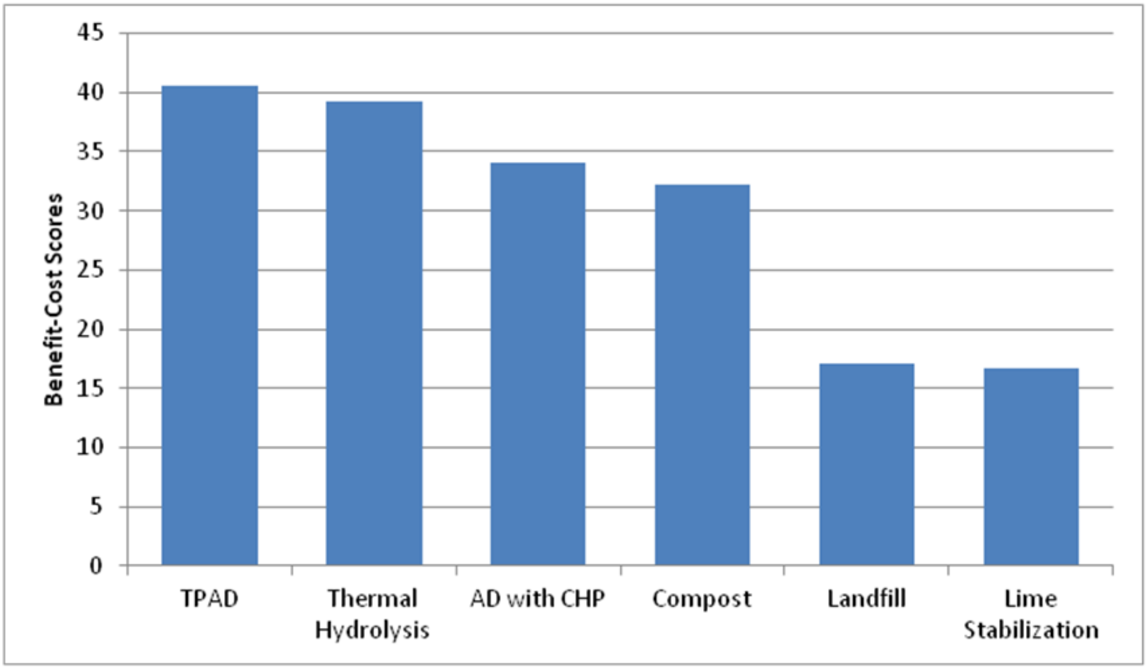

Figure 2: Benefit-cost Scores, South Plants

For both the North and South Plants, it was recommended that the AD alternatives: Mesophilic AD, Thermal Hydrolysis, and TPAD be evaluated in greater detail for further analysis. Each of these alternatives includes converting the energy rich biogas from the process to combined heat and power for use at the facilities.

Refined Comparison of Anaerobic Digestion Alternatives

A refined comparison of the three AD alternatives was performed focusing on the differences between the options; this did not consider components that were common to all three alternatives. The assumptions and costs associated with the alternatives were refined, and the thermal hydrolysis vendors were engaged to optimize the phasing of new equipment installation to accommodate their equipment sizing more cost effectively.

The results of the comparison eliminated TPAD as one of the options recommended for further consideration. While the TPAD product meets Class A Biosolids requirements, it was eliminated from further consideration for two main reasons—biosolids product marketability and system operability. The product marketability of the TPAD product would be limited due to physical characteristics and odors that could impede beneficial reuse of the product. The operation of TPAD would be more complex than conventional AD and more prone to process upsets than thermal hydrolysis. Given the physical characteristics of the TPAD biosolids product, the additional complexities associated with operating a TPAD system were not warranted.

The two remaining options, conventional AD and thermal hydrolysis in conjunction with mesophilic AD, were within 4 percent of one another for the NPV over the planning period. There are significant differences in the potential energy production and operational complexities of these two options. It was recommended that District staff further consider these two options during a subsequent preliminary engineering evaluation. It was also recommended that District staff examine facilities that have implemented these systems to have a better understanding of operating the systems.

Medium Sized Facilities Evaluation

Given that the AD alternatives looked favorable for the larger plants operated by the District, an analysis of the medium-sized facilities was conducted to determine if AD would be a long-term, cost-effective solution for these facilities. The plants considered were Floyd Branch, Muddy Creek, and Panther Creek (with solids from Stewart Creek) WWTPs.

The evaluation compared conventional AD to the current practice of landfilling unstabilized material. These results indicated that continued landfilling is currently the most economical solution over the planning period. The results of the benefit-cost evaluation are presented in Figure 3, which indicate that continued landfilling is also the best option with non-monetary factors taken into account. Of note is that the scoring discrepancy between landfilling and digestion is largest for Floyd Branch. This is because the digestion system at Floyd Branch would be smallest of the three systems, equivalent to 30% of Muddy Creek's capacity and 20% of Panther Creek's capacity. Digestion's capital investment is more cost-effective with larger facilities. After the District has an opportunity to implement and operate an AD system at the larger facilities and has a better understanding of operating the system, it was recommended that implementation of AD at the medium-sized facilities be reconsidered.

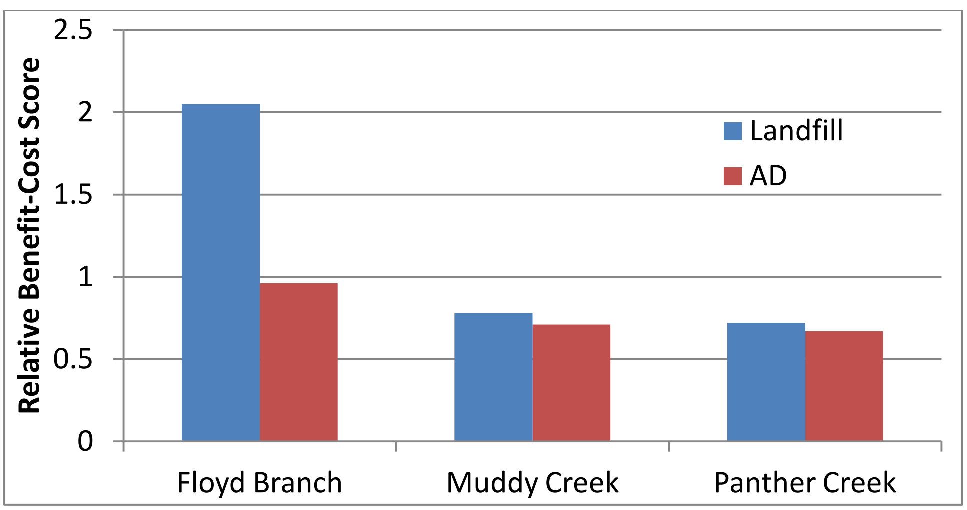

Figure 3: Relative Benefit-cost Scores, Medium-sized Plants

Final Results and Recommendations

The resulting recommendations were to move forward with preliminary engineering of AD to process the wastewater residuals at both the Wilson Creek and South Mesquite Regional Wastewater Treatment Plants (RWWTPs). The alternative selected could either be conventional mesophilic AD, thermal hydrolysis pretreatment followed by conventional mesophilic AD, or a phased implementation of the latter.

The cost of thermal hydrolysis technology has become more competitive in recent years, and vendor systems have improved to reduce capital expenses and reduce odor emissions from the process. Utility experience with combined heat and power systems has increased, and more utilities now view biosolids as an energy resource, whose power generation capacity can significantly offset electrical costs for a facility.

Figure 4 represents an estimate of the cost savings that would be realized by phased implementation of thermal hydrolysis pretreatment followed by conventional mesophilic AD for Wilson Creek RWWTP. The savings shown in Figure 4 are the net difference of the total estimated annual cost of the AD option versus the existing method of landfilling wastewater residuals. Savings would begin to be realized upon startup of the AD system. The savings would increase over time as energy production increases (with increased plant flows and wastewater residuals) and landfill disposal costs increase.

It was recommended that the District move forward with preliminary engineering to further define the AD process most appropriate for implementation. With the significant technological advances that have occurred over the previous decade, there is an opportunity for the District to realize long-term cost savings while shifting to a more sustainable approach by implementing AD projects at the Wilson Creek RWWTP and South Mesquite RWWTP.

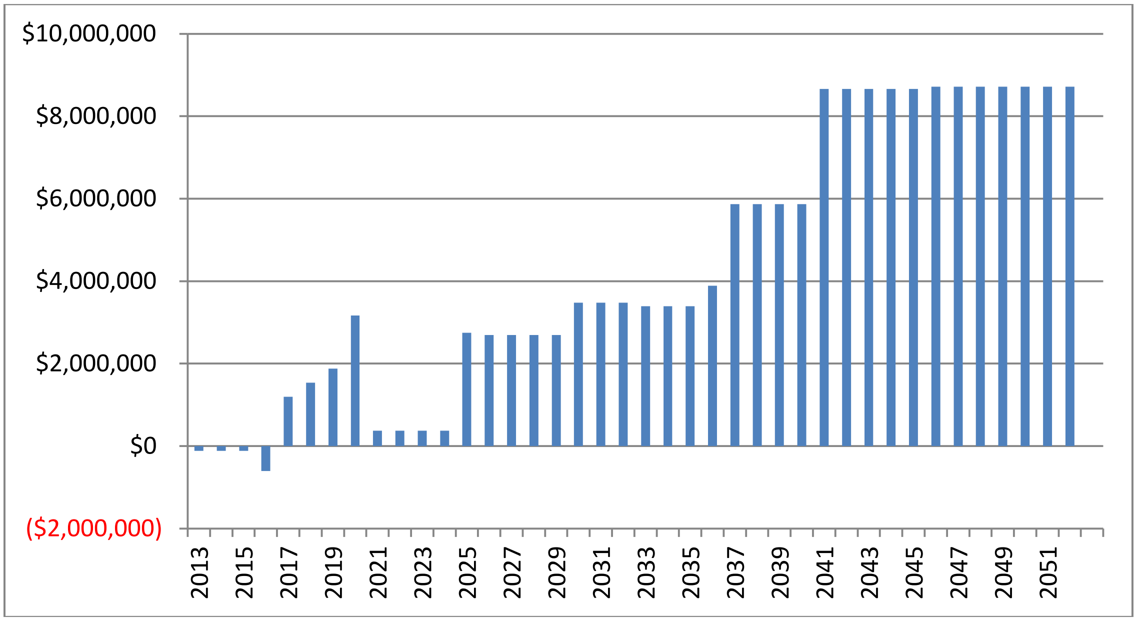

Figure 4: Wilson Creek Regional Wastewater Treatment Plant – Projected Annual Savings through Thermal Hydrolysis and Mesophilic Anaerobic Digestion

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End Notes

1 Benefits = The scoring from the non-monetary evaluation; Cost = the net present value of the alternative over the time horizon.

2 Unclassified Solids: Must be disposed of in landfill.

3 The SlurryCarb™ process would occur after dewatering. Dewatered cake would enter a thermal hydrolysis process fueled by methane. Additional post- dewatering would follow. The process would create a dewatered product at 45 to 50 percent dry solids. Since the study was initiated, the only operating SlurryCarb™ process in Rialto, California was closed.

4 Class B Biosolids: Treated wastewater residuals so that the pathogen content is reduced and acceptable for land application; however, in Texas the public comment period required for land application of Class B Biosolids has driven many facilities to Class A Biosolids.

5 Class A Biosolids: Unrestricted use of treated wastewater residuals; can be distributed directly to the public.

6 SlurryCarbTM and Landfill Biogas –fueled Thermal Drying were not considered for the South Plants due to landfill biogas not being available to fuel the process.

7 Benefit divided by the cost