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Final Report

Prepared for: King County Department of Natural Resources and Parks

Project Title: Mechanical-Electrical On-Call Services: Grease Study Task Order

Project No: 141326.002.040

Executive Summary

Subject: South Plant Grease Study Final Report

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1. Introduction

King County Department of Natural Resources and Parks (DNRP) Wastewater Treatment Division's (WTD) published vision is, "Creating Resources from Wastewater." With the completion of the Brightwater Advanced Wastewater Treatment Plant, flows from North Creek and York Pump Stations will be diverted away from South Treatment Plant resulting in increased capacity in the South Plant digesters. One potential use for this additional capacity that would be in line with the WTD's vision statement would be the acceptance of brown grease, the grease collected in grease traps and grease interceptors at food services establishments (FSEs) and food processors, in South Plant's existing digesters.

Brown grease is typically handled as a waste product, often being dewatered and landfilled. Primarily made up of fats, brown grease is of high calorific value and thus energy and can be anaerobically biodegraded to produce biogas just as sewage sludge is currently being digested at South Plant. The addition of brown grease to sewage sludge for co-digestion is not a new practice; wastewater facilities in Riverside, California (East Bay Municipal Utility District), Oxnard, California, Millbrae, California, and Waco, Texas currently co-digest at their wastewater treatment facilities. In the Pacific Northwest, several utilities are either moving toward utilizing brown grease beneficially (Clean Water Services, Oregon, and Metro Vancouver, British Columbia) or have investigated its use (Tacoma, Washington, Medford, Oregon, and Bellingham, Washington).

To investigate the potential ramifications of adding co-digestion to the South Treatment Plant process, an investigation into the available process capacity was performed and a business case evaluation (BCE) was developed to evaluate the financial viability of a conceptual co-digestion facility layout. This report summarizes the findings of these investigations and includes the detailed technical memoranda developed as attachments. In addition, comments from King County staff during review of the facility layout technical memorandum are included as an attachment to aid future detailed design efforts.

2. Capacity Analysis

The capacity of the four existing anaerobic digesters and sludge blend tank at South Plant to accept brown grease is limited by two factors: the organic loading rate and the hydraulic retention time. The organic loading rate is defined as the amount of volatile organics loaded to a unit volume over a specific time period. For grease loading this is limited to 30 percent of the daily sludge load based on best engineering practice. The hydraulic retention time is defined as the active volume divided by flow rate. The hydraulic limit of the digesters at South Plant was defined as a 20 day retention period under all flow and load conditions. This was based on WTD operator experience and to maintain process operating conditions for stable operation and superior biosolids product quality while meeting the United States Environmental Protection Agency's (EPA) requirement of significant pathogen reduction.

The capacity analysis found that the one digester out of service at average annual flows and loads condition dominated the capacity limits for brown grease acceptance. Figure ES-1 and Figure ES-2 were developed for multiple grease mass flow rates and concentrations and show organic loading limits as well as hydraulic limits. Assuming a 30% load fraction and 5% grease concentration, the South Plant digesters have organic loading capacity to 2028 and hydraulic loading capacity to 2020.

Further capacity analysis of biogas end use equipment capacity indicated that the waste gas burners may begin to become limiting in 2024, depending on the operating strategy (number of duty burners) and the level of additional gas production from co-digestion.

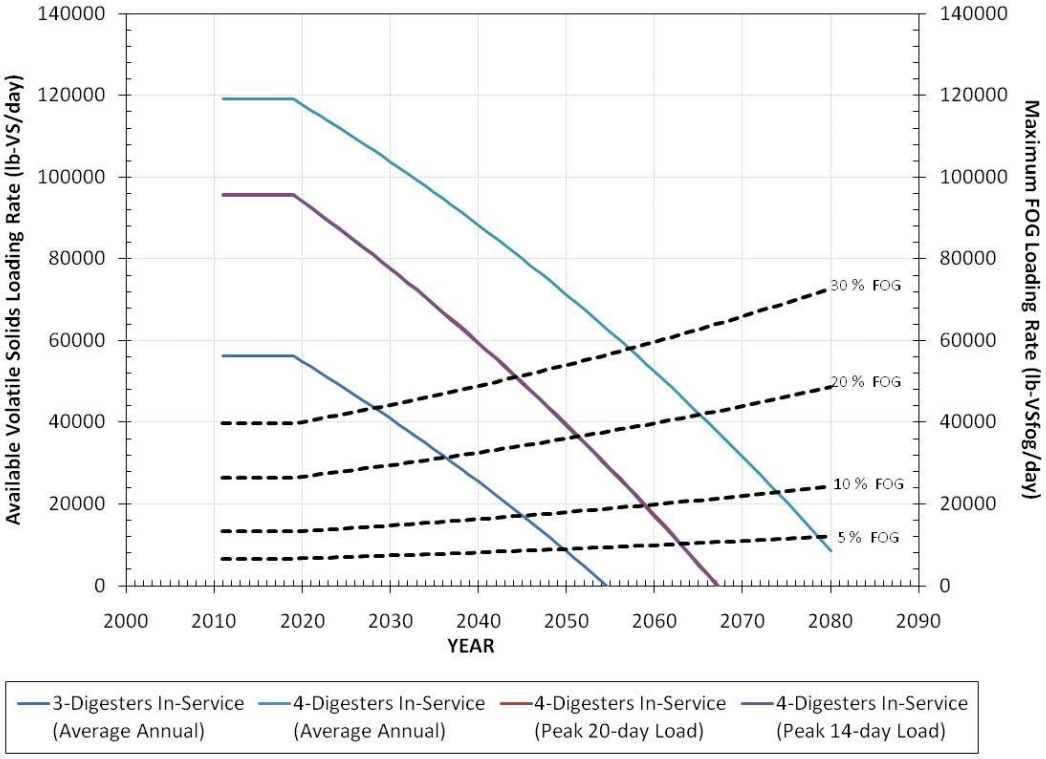

Figure ES-1. The utilization of organic loading capacity at South Plant a variable load fractions of brown grease

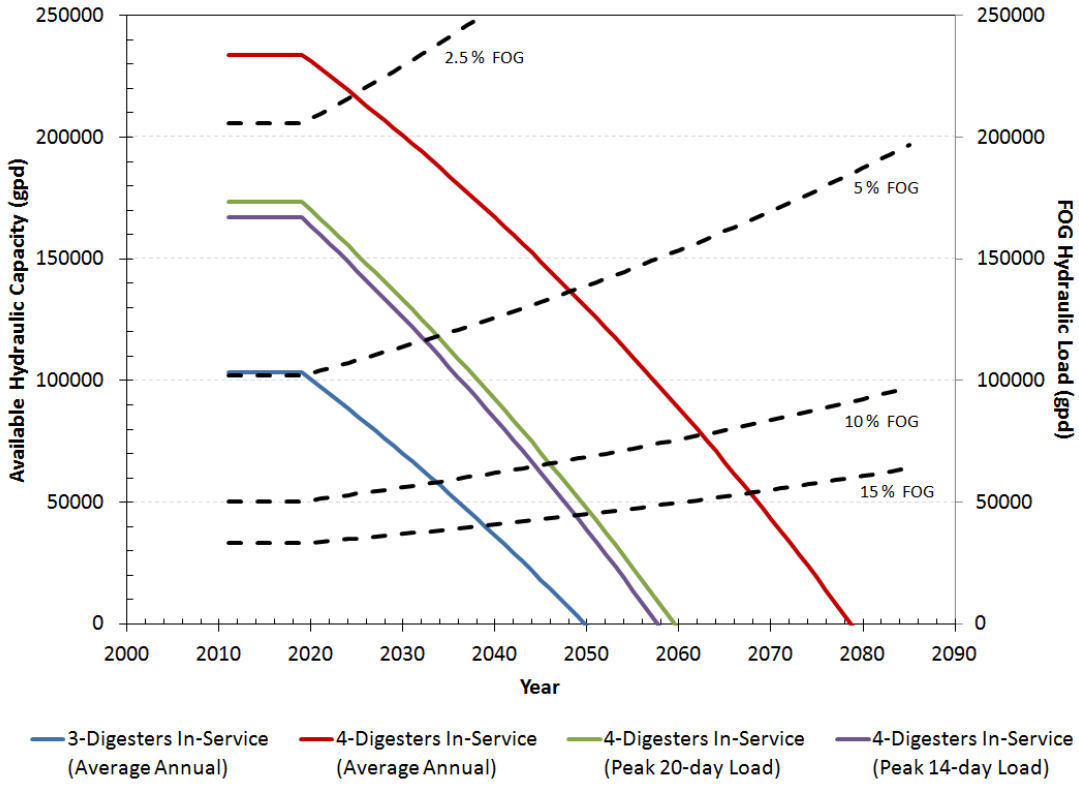

Figure ES-2. Influence of brown grease solids concentration on the hydraulic capacity of South Plant's digesters at a FOG volatile solids loads of 30 percent of average annual sludge

3. Facility Layout and Business Case Evaluation

Based on the results of the capacity analysis, a conceptual facility was developed that would allow for an initial demonstration facility sized for demonstrating co-digestion on one digester (31,000 gallons per day at 4.6% solids) as well as a full capacity facility that would accept the maximum load available (123,000 gallons per day of grease at 4.6% solids). To address the hydraulic limitations of the system a scum concentrator was included to increase grease concentrations to 20% solids. This thickening of the grease decoupled organic loading limits from the hydraulic loading limit and allowed for capacity to be extended to 2030. The disadvantage of this addition was that recycled BOD from the thickening will increase operational costs in the secondary treatment process.

A process flow diagram of the full capacity facility is presented in Figure ES-3 and a general layout of both the full facility and the demonstration facility is shown in **Error! Reference source not found.**5.

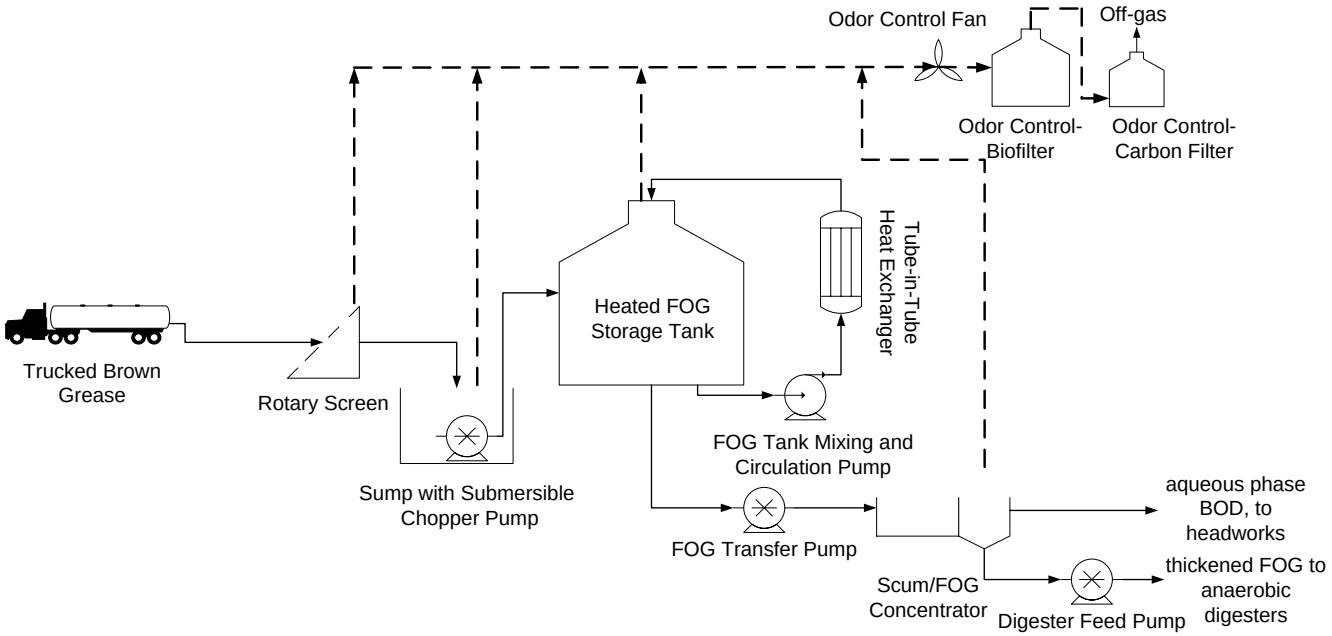

Figure ES-3. Basic process flow schematic of conceptual grease facility for South Plant

Based on this conceptual design, a BCE was conducted to assess the 20-year net present value (NPV) of both the demonstration facility and the full capacity facility. To conduct this analysis, a conceptual cost estimate was developed, operational costs were estimated, and potential revenues were included. These costs are summarized in Table ES-1. Based on a total construction cost of $4.52 million, including County allied costs, the 20-year NPV was estimated to be $15.65 million, indicating that executing the project as defined would be a benefit to the County. Should the County decide to just build the demonstration facility, construction costs were expected to be $1.24 million (including all allied costs) and a 20-year NPV return of $5.18 million was calculated. This indicates that just building the demonstration facility would be economically positive for the County over a 20-year period.

Because a number of assumptions built into these analyses have not been confirmed, a sensitivity analysis was conducted to investigate the impact of tipping fees charged to haulers and the amount of grease received daily on a volumetric basis. This analysis indicated that at a tipping fee of 5 cents per gallon, the demonstration facility would be economically viable at inflows as low as 16,000 gallons per day and the full capacity facility would be viable at flows as low as 60,000 gallons per day.

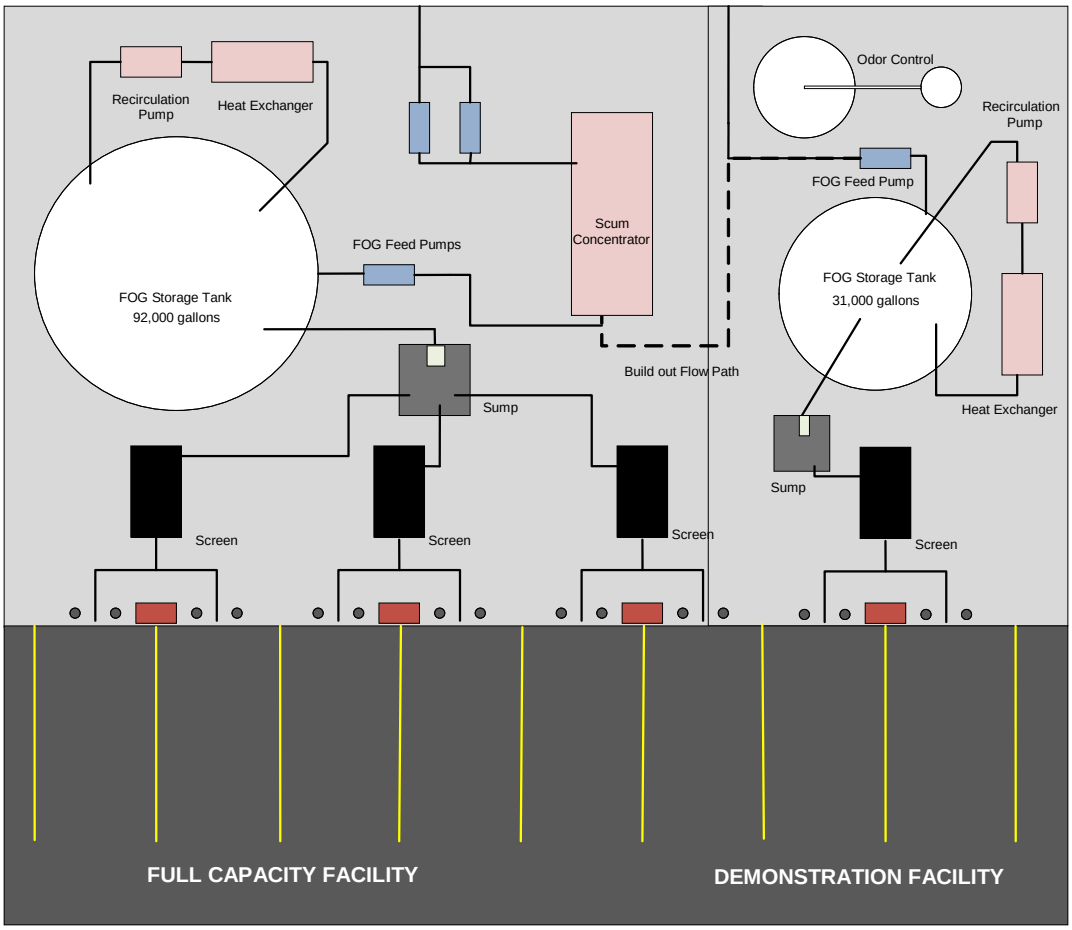

Figure ES-4. Conceptual grease receiving facility layout for South Plant

Table ES-1. 20-Year Cost and Revenue Breakdown for Grease Receiving at South Plant

Description	Rate	Capital costs ($-million)	Total operating costs ($-million)	Total revenues ($-million)
Capital and allied costs				
Demonstration facility capital cost[a]		0.923		
Demonstration facility allied costs		0.318		
Full capacity expansion costs[a]		2.440		
Full capacity expansion allied costs		0.835		
Total capital and allied costs		4.52		
Operating costs				
Labor costs (admin and operations)	48.10 $/hr		7.96	
Power cost	0.065 $/kW-hr		2.69	
Carbon media replacement			0.037	
Biogas upgrading costs: FOG gas			5.83	
Treatment cost of recycled BOD	0.10 $/lb-BOD treated		24.28	
Biosolids disposal costs	39$/wet ton		14.94	

Dewatering polymer costs	1.05 $/lb polymer		8.10	
Total 20-year operating costs			63.84	
Revenues				
Biogas sale to PSE	$0.55914 per therm			14.86
Tipping fees	0.05 $/gal			79.14
Biosolids fertilizer surcharge	1.50 $/wet ton			0.57
Total 20-year revenues				94.57

[a] *Class 4 cost estimate per AACEI, carries a level of accuracy of -30% to +50%.*

4. Recommendations

Based on the capacity analysis and BCE, a full capacity co-digestion facility is considered viable at South Plant. Before construction of a full-capacity system can be recommended however, several assumptions, process parameters, and conditions should be validated to better execute the design of the full capacity facility and associated program. These include:

- **Market conditions:** A market analysis was not performed as part of this analysis. Therefore, it is important to ascertain if sufficient brown grease can be directed to South Plant to meet program demands. Other materials that could be used to supplement the program (e.g., food processing wastes) could also be investigated as part of this investigation.
- **Tipping fees:** Assessing the current rates being paid by grease haulers would allow the County to charge the maximum tipping fee to support revenues while still being sufficiently attractive to bring haulers to South Plant.
- **Grease characteristics:** The biochemical and physical characteristics of brown grease have been documented in the literature, but vary widely from location to location. Assessing local conditions will allow for modifications to the design (e.g., remove the need for a scum concentrator) and remove some of the uncertainty in the BCE results.
- **Synergistic effects:** There is anecdotal evidence in the literature that adding brown grease to digesters in sufficient quantities can improve process efficiency resulting in more biogas and fewer biosolids than if the materials were treated separately. Better understanding these limits could have a significant impact on the long-term benefits of operation, increasing revenues from gas while decreasing costs associated with dewatering and biosolids disposal.

To address these unknown areas, we recommend the County construct the demonstration facility as shown in the conceptual facility layout and assess the results from operating the facility before moving forward with the full-capacity facility. Operating the demonstration facility alone has a positive net present value and would provide the County with necessary information regarding the local grease market, characteristics of the grease being brought to the facility, possible synergistic effects, and any potential operational or maintenance concerns from operating the facility. Should these assumptions validate the BCE performed for the full-capacity facility, the full facility can be refined and constructed at a later date.