

Commonwealth Energy Biogas/PV Mini-Grid
Renewable Resources Program

***Making Renewables Part of an Affordable and
Diverse Electric System in California***

Contract No. 500-00-036

Draft Monthly Data Report for July, 2005

Project 3.1 Co-digestion of Dairy Manure/Food Processing
Wastes and Biosolids /Food Processing Wastes to Energy

Task 3.1.5 Operate and Test Pilot (Demonstration) Plant(s)

Prepared For:
California Energy Commission
Public Interest Energy Research Renewables Program

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Acronyms and Abbreviations

AFT	Applied Filter Technology
BFP	belt filter press
Btu/cf	British thermal units per cubic foot
CEC	California Energy Commission
cf/lb	cubic feet per pound
CO ₂	carbon dioxide
DAF	dissolved air flotation
DAFT	dissolved air flotation thickener
dtpd	dry ton per day
FID	flame ionization detector
FS	fixed solids
g/cm ³	gram per centimeter cubed
K gpd	1,000 gallon per day
gpm	gallon per minute
H ₂ S	hydrogen sulfide
HRT	hydraulic retention time
IA/PA	volatile acids (VA) : Alkalinity ratio (expressed as "IA/PA" in IEUA analytical protocols)
IEUA	Inland Empire Utilities Agency
lb/d	pound per day
K lb/d	1,000 pound per day
cf/hr	cubic feet per hour
K cf/hr	1,000 cubic feet per hour
K gal/d	1,000 gallons per day
cfm	cubic feet per minute
cf/d	cubic feet per day
K cf/d	1,000 cubic feet per day
lb/gal	pound per gallon
µg/L	micrograms per liter
MG	million gallon
mgd	million gallon per day
mg/L	milligram per liter
NRW	non-reclaimable waste
PIER	Public Interest Energy Research
ppmv	part per million by volume, dry
ppm	part per million
psig	pound per square inch gauge
PS	primary sludge
SiO ₂	silicone dioxide
SLR	solids loading rate
SWD	side water depth
TDS	total dissolved solid

TKN	total Kjeldahl nitrogen
TPS	thickened primary sludge
TS	total solids
TSS	total suspended solid
TWAS	thickened waste activated sludge
VA	volatile acids
VS	volatile solids
VSR	volatile solids reduction
WAS	waste activated sludge
wtpd	wet ton per day

SECTION 1

Introduction

In late August 2005, the California Energy Commission (CEC) authorized the contractor to proceed with Project 3.1 – Co-Digestion of Dairy Manure/Food Processing Wastes and Biosolids/Food Processing Wastes to Energy. The goals of this project are to:

- Develop technologies that will address the lack of knowledge of the relationship between various co-digestion feedstocks and gas production. Pilot (demonstration) scale systems will be developed to yield information on the direct relationship between the physical and chemical characteristics of the feedstocks and the operating parameters of the co-digestion system and the increase in gas production associated with their co-digestion.
- Provide information for future users on the development of optimal blends or “cocktails” for co-digestion projects.
- Quantify the potential environmental benefits of dairy waste to energy projects in such a way that their values can be identified as individual projects are being implemented.
- Report the results of studies that led to the establishment of the foregoing goals.

Task 3.1.5 in Project 3.1 calls for (1) operating the plant and conducting co-digestion tests in accordance with the test plan, and (2) preparing monthly plant operating data reports to verify that the pilot (demonstration) plant meets performance requirements (e.g., throughput, environmental requirements, waste processing, and gas production/energy recovery).

Pilot tests for co-digestion of both dairy manure/food processing wastes and biosolids/food processing wastes to energy have been conducted at the Inland Empire Utilities Agency (IEUA) Regional Plant No. 1 (RP-1) since April 2005. This report presents the plant operational and performance data obtained during the month of July 2005.

SECTION 2

Co-Digestion Performance Summary

2.1 Co-Digestion Inputs

Table 2-1 below shows inputs to the co-digestion systems for dairy manure, biosolids and food waste. For the biosolids test, flows into digester #1 are shown, with the effluent amounts (flow, total solids (TS) and volatile solids (VS)) apportioned to digesters 2, 6 and 7.

TABLE 2-1 Inputs to Co-Digestion Systems for Dairy Manure, Biosolids, and Food Waste				
INPUTS	FLOW (GPD)	TS (LBS/DAY)	VS (LBS/DAY)	AVG. % SOLIDS (%TS)
1) Co-digestion of dairy manure/food processing wastes				
Digester 4				
Dairy manure	25,980	33,230	26,720	15.3%
Food processing wastes				
Salad Dressing	160	339	318	25.2%
Lactose	510	303	237	7.2%
Ice Cream	410	567	550	16.8%
Total	27,060	34,440	27,830	15.0%
2) Co-digestion of biosolids/ food processing wastes				
Digester 1				
Biosolids	216,240	71,749	55,749	4.0%
Food processing wastes ¹				
Salad Dressing	303	321	285	12.8%
Lactose	2,414	1,712	1,424	8.5%
Ice Cream	2,656	5,050	4,935	22.8%
Total	221,610	78,830	62,390	
Distribution of Digester 1 Effluent: Feed to Digesters 2,6 and 7:				
Digester 2	59,250 ¹	16,740	12,390	3.4%
Digester 6, 7	81,460 ¹	23,020	17,030	3.4%

¹ Food waste was added to Digester 1 from DAFT3. The flow here is the proportioned amount based on the flow distribution ratio from Digester 1 to Digesters 2, 6 and 7. Average number includes zeros.

Totals rounded to the nearest 10.

2.2 Digester Performance Data

Table 2-2 below shows performance parameters for digesters 4 (manure co-digestion), 1, 2, 6 and 7 (biosolids co-digestion):

TABLE 2-2 Digester Performance						
1) Co-digestion of dairy manure/food processing wastes		Units	Digester 4			
VS loading rate	lbVS/cf active volume ³		0.271			
Hydraulic Retention Time	Days		25			
Digester Temperature	°F		99			
pH changes over time	pH (range)		7.4 - 7.65			
Iron Salt Addition	gpd		166			
Volatile Solids (VS) Reduction	VS in Output/VS in Input, %		45%			
Gas Yield	cf/lb VSR		6.0			
CH4 in Biogas	%		56%			
CO2 in Biogas	%		34%			
H2S in Biogas	ppm		57			
2) Co-digestion of biosolids/food processing wastes			Digester 1	Digester 2	Digester 6	Digester 7
VS loading rate	lbVS/cf active volume ³		0.509	0.102	0.076	0.076
Hydraulic Retention Time	Days		3.3	15	20	20
Digester Temperature	°F		98	125	98	118
pH changes over time	pH (range)		5.2 – 5.4	7.3 – 7.7	7.1 – 7.5	7.4 – 7.8
Volatile Solids (VS) Reduction	VS in Output/VS in Input, %		11%	38%	39%	43%
Biogas Yield	cf/lb VSR		3	56	29	27
CH4 in Biogas	%		N/A ⁴	N/A ⁴	N/A ⁴	N/A ⁴
CO2 in Biogas	%		N/A ⁴	N/A ⁴	N/A ⁴	N/A ⁴
H2S in Biogas	ppm		N/A	N/A	N/A	N/A

¹ Food waste was added to Digester 1 from DAFT3. The flow here is the proportioned amount based on the flow distribution ratio from Digester 1 to Digesters 2, 6 and 7. Average number includes zeros.

² Digester Free Board Level is the actual operational level measured. Digesters 2 and 6 side wall depths are 30 ft.

³ Digester's active volume was calculated based on digester SWD (30 ft) and with cone volume

⁴ Measurement of CH4 and CO2 content in biogas for biosolids digesters did not begin until August 2005.

Flow, mass and gas production data were rounded to the nearest 10.

NA: Not Available or Not Applicable

The focus of the monthly reporting was on digesters 2 and 6. Detailed graphical data showing trends for the above parameters for digesters 2 and 6 are shown in the body of this report.

2.3 Cost Data

2.3.1 Installation Costs

Total installation costs for the co-digestion equipment at RP-1 for conducting these tests are shown in Table 2-3 below. Costs to install iron sponge modifications, which were indirectly related to the co-digestion project, are shown and broken out as well.

TABLE 2-3

Co-Digestion and Iron Sponge Project Installation Costs

	Co-Digestion	Iron Sponge Modifications	Total	Comments
Raw Materials	\$ 562,000	\$ 14,000	\$ 576,000	Includes food-waste tanks, pumps, media for iron sponge
Total installation subcontracts	\$ 226,000	\$ 158,000	\$ 384,000	
Host site (IEUA) General & Administrative	\$ 79,000	\$ 17,000	\$ 96,000	10% of (Raw Materials + Installation costs)
CH2M HILL cost (design and engineering)	\$ 85,000	\$ 31,000	\$ 116,000	
TOTAL	\$ 952,000	\$ 220,000	\$1,172,000	

NOTE: All costs rounded to nearest \$1,000.

These costs are one-time costs to the project, and will be recorded again for reference only in subsequent monthly data reports for Task 3.1.5.

In addition, approximately \$1.3 million was spent by IEUA on safety and performance upgrades to the existing gas handling system. These changes has already been identified as necessary before the project, however the addition of co-digestion increased the urgency of this project. For estimating purposes, approximately 1/3 of this cost, or about \$433,000 could be applied in addition to the direct costs of the co-digestion project shown above. It is anticipated that similar expenditures could be needed at other facilities in California where co-digestion projects are installed.

2.3.2 Operations and Maintenance Costs

For the month of July, 2005, total operations and maintenance costs were estimated at \$ 23,600, broken out as follows:

- \$ 2,900 host site (IEUA) labor and administrative costs

- \$ 9,300 subcontracted operators and lab costs
- \$ 11,400 costs from CH2M HILL

These costs include laboratory testing costs as well as standard operating costs. For a full-scale system, the laboratory tests would not be included.

SECTION 3

Food Waste Received for Manure and Biosolids Co-Digestion Test

This section provides a summary of the food waste delivered to the RP-1 plant during the month of July 2005. The food waste delivered was used for both manure and biosolids co-digestion tests and included salad dressing waste from GFF, Inc. (normally delivered on Wednesdays), lactose waste from AJ Juice, and ice cream waste from Alta Dena, delivered over the week.

Figure 3-1 shows the combined food waste flow that has been fed to the manure (Digester 4) and biosolids train for co-digestion tests.

Figure 3-2 presents the total solids (TS) concentration and volatile solids (VS) content of the TS of the food waste, by type, that has been fed to the manure (Digester 4) and biosolids train for co-digestion tests.

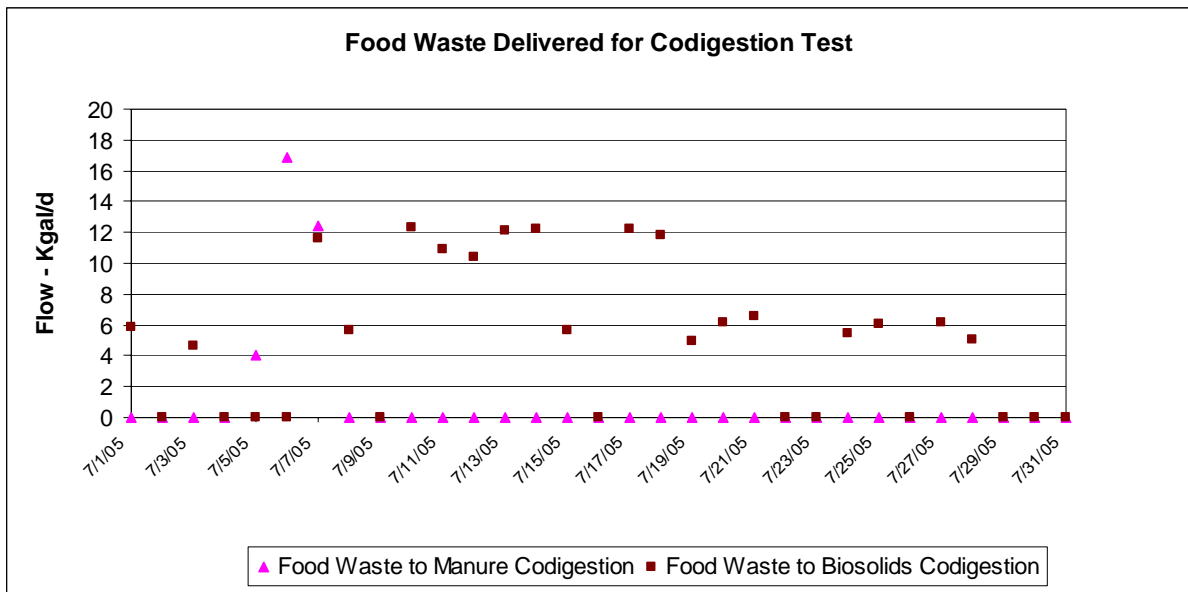


FIGURE 3-1
Combined Food Waste Flow Delivered for Co-digestion Test During the Month of July 2005

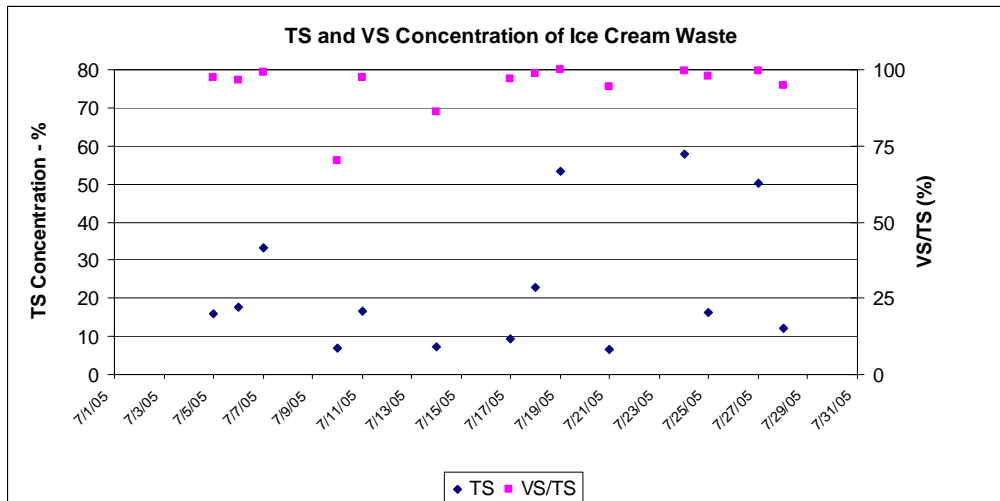
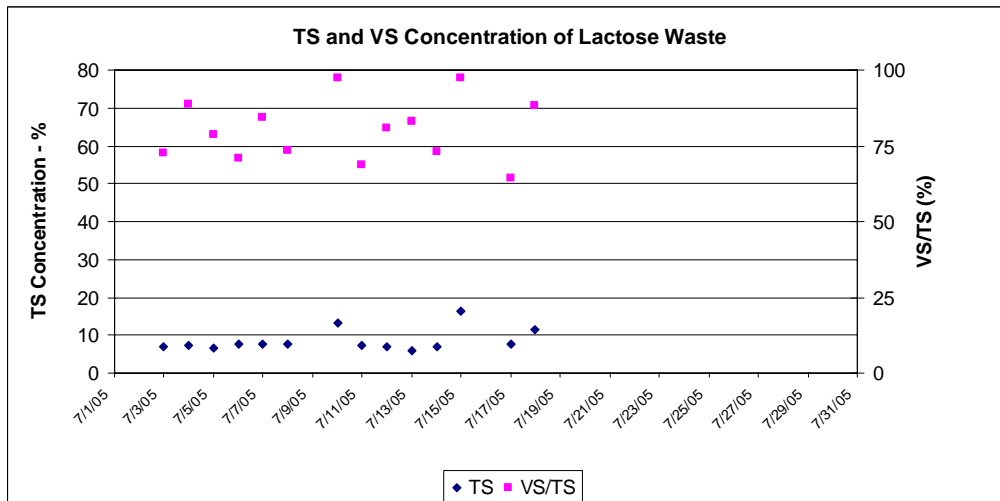
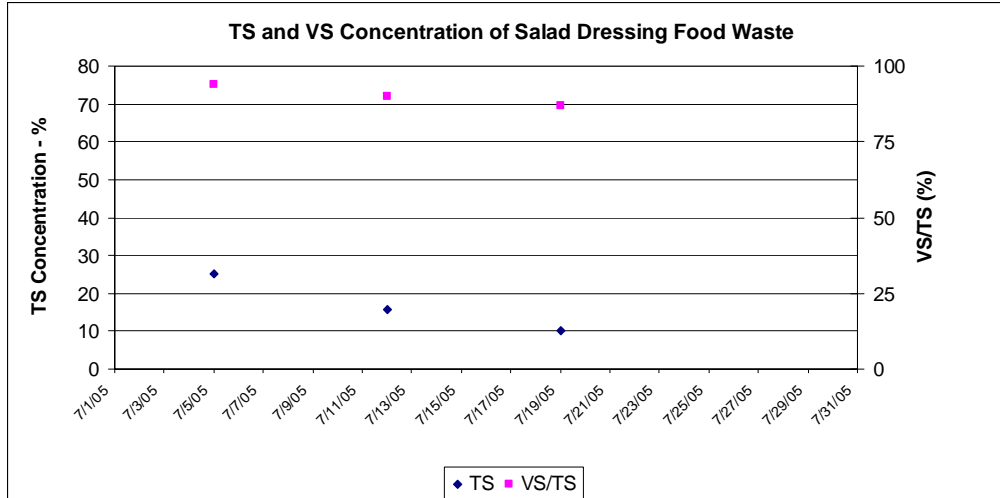


FIGURE 3-2
TS Concentration and VS Content of the Food Waste Delivered by Type

Manure and Food Waste Co-Digestion

This section provides operational and performance data obtained from manure and food waste co-digestion tests during the month of July 2005.

4.1 Manure and Food Waste Co-Digestion Operations with Digester 4 at RP-1

4.1.1 Manure Digestion at RP-1

In 2002, IEUA retrofitted an existing digester (Digester 4) located within the Agency RP-1 facility to accept dairy manure. RP-1 currently serves a cluster of seven dairies within 5 miles, which makes it an ideal location for a centralized dairy manure digestion facility. Manure is collected daily from the dairies' feed lanes by means of a vacuum tanker truck called the "honey-vac" and is transported daily to the RP-1 digester in a nurse tanker. The vacuum nurse tanker has a holding capacity of 5,500 gallons, and roams from dairy to dairy picking up manure slurry that has been temporarily stored in a holding tank and delivers it to the manure digestion facility at RP-1. These units provide efficient, clean transportation of manure from the dairies to the manure digester at RP-1. Under normal operations, the plant receives five to seven loads per day of dairy manure. Before July 2005, the trucked manure was fed to an acid manure digester (AMD) first; from there, it was fed to Digester 4. Since July, the trucked manure has been fed directly to Digester 4.

4.1.2 Food Waste and Dairy Manure Co-Digestion at Digester 4

Beginning in early April 2005, the RP-1 plant initiated a co-digestion project by adding food waste to the dairy manure fed to Digester 4. The food wastes are trucked to the plant on a daily basis, stored temporarily in the four food waste storage tanks, and fed to the manure digester and biosolids digestion trains from there. Prior to the full-scale pilot project, bench-scale testing of manure and food waste co-digestion was conducted at mesophilic and thermophilic conditions. Bench-scale testing showed that the microbial population in the digester can be stressed much more easily and rapidly at thermophilic temperatures; therefore, the full-scale testing of manure and food waste was conducted at mesophilic temperatures.

4.1.3 Co-digestion Facility at RP-1

Figure 4-1 shows the manure and food waste co-digestion facility at RP-1.



FIGURE 4-1
Manure and Food Waste Co-digestion Facility at RP-1

4.2 Digester 4 Operational Parameters

Because digester operational parameters affect digester performance, it is necessary to monitor these parameters in relation to digester performance. For this full-scale test, digester operational parameters that are monitored include feed characteristics (e.g., flow and solids concentrations of the dairy manure and food waste), VS loading rate, hydraulic retention time, pH, alkalinity, and digester operational temperatures. Figures 4-2 to 4-5 present the digester feed flow and solids concentrations, VS loading rate, and hydraulic retention time. Monthly averages for operational parameters are discussed in Section 4.4.

4.2.1 Feed Manure and Food Waste

Figure 4-2 shows the manure and food waste flow added to Digester 4 during the month of July 2005. The food waste flow is the combined amount of the salad dressing, lactose, and ice cream wastes received in the plant and fed to the manure digester the same day.

Figure 4-3 presents the TS concentration and VS content of the manure that has been fed to Digester 4.

Table 4-1 presents Digester 4 monthly average data for feed and feed characterization for July 2005.

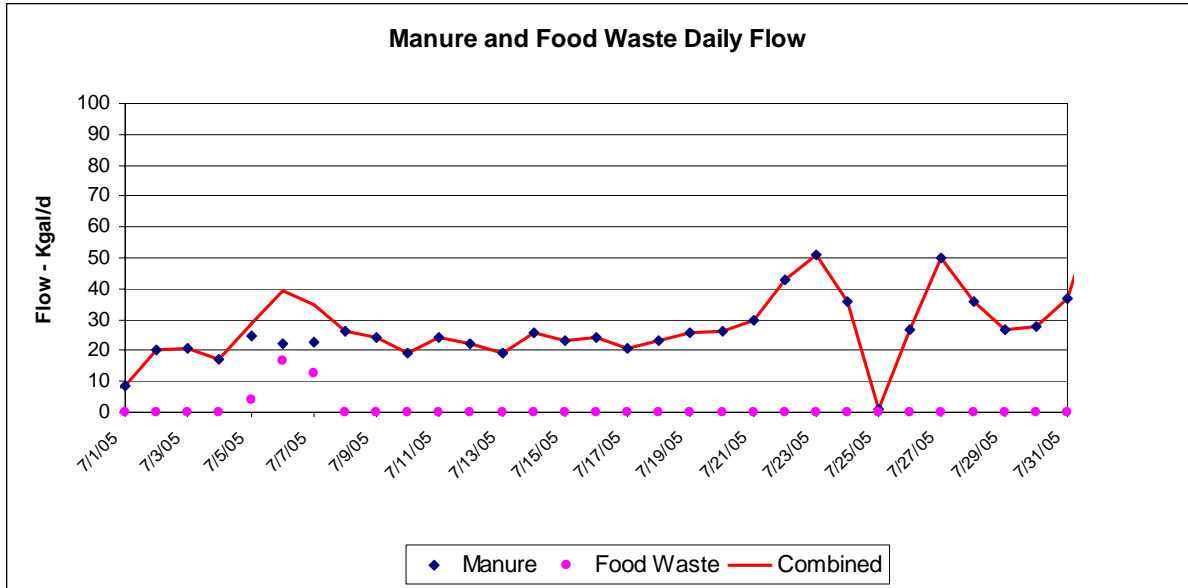


FIGURE 4-2
Digester 4 Manure and Food Waste Daily Flow

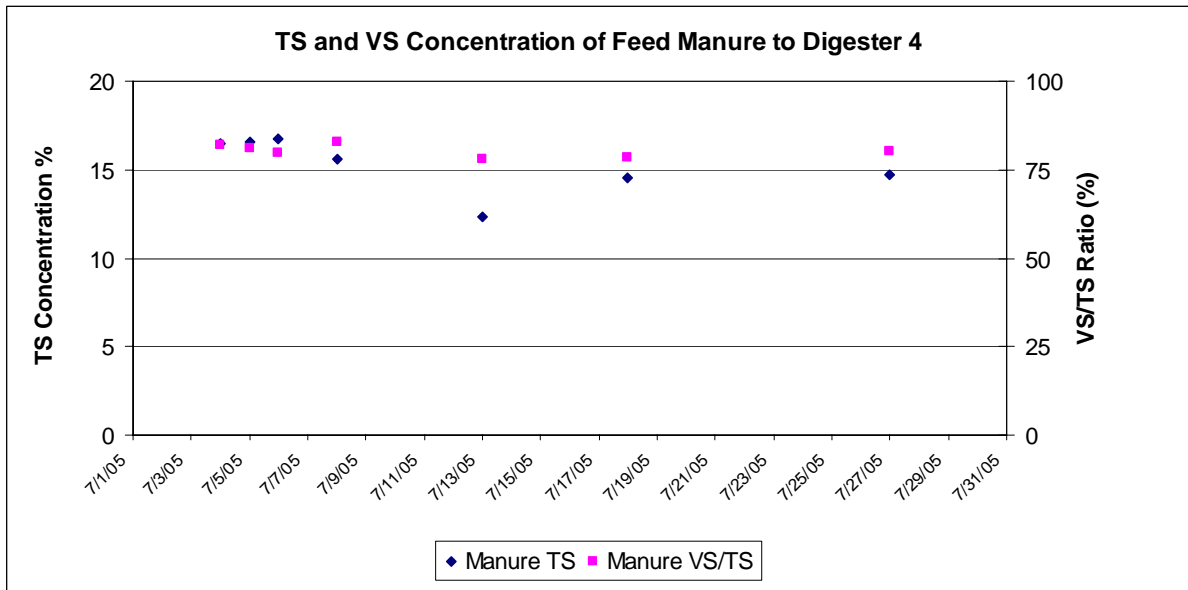


FIGURE 4-3
TS Concentrations and VS Content of the Manure Fed to Digester 4

TABLE 4-1
Digester 4 Monthly Average Data for Feed and Feed Characterization for July 2005

Parameter	Units	Manure Feed	Food Waste		
			Salad Dressing	Lactose	Ice Cream
Flow ¹	gpd	25,980	160	510	410
TS	%	15	25 ²	7 ²	17 ²
VS	% of TS	80	93 ²	79 ²	97 ²
pH		NA	NA	NA	NA
Alkalinity	mg/l	NA	NA	NA	NA
Temperature	°F	NA	NA	NA	NA
Volatile Acids	mg/l	NA	NA	NA	NA
Total Organic Carbon	mg/l	NA	NA	NA	NA
COD, mg/L	mg/l	NA	NA	NA	NA
NH ₄ -N	mg/l	NA	NA	NA	NA
TKN	mg/l	NA	NA	NA	NA
Proximate Analysis		NA	NA	NA	NA

Notes:

¹ Average flow includes zero values. Numbers were rounded to the nearest 10.

² Missing values were filled with previous or adjacent days' test results.

4.2.2 Solids Loading Rate (SLR)

Figure 4-4 shows the VS loading rate for Digester 4 during the month of July.

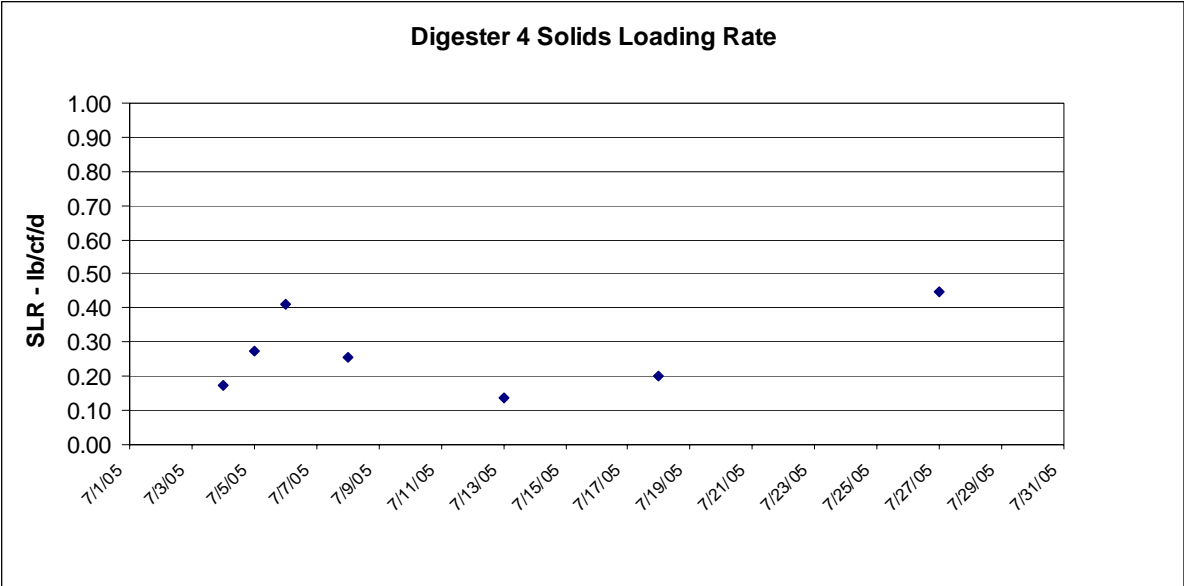


FIGURE 4-4
Digester 4 Volatile Solids Loading Rate (Manure and Food Waste Combined)

4.2.3 Hydraulic Retention Time (HRT)

Figure 4-5 shows the hydraulic retention time in Digester 4.

On July 25, the manure load was only 1.2 K gal/d. The calculated hydraulic retention time (HRT) was high (553 days); therefore this data point was not included in this chart.

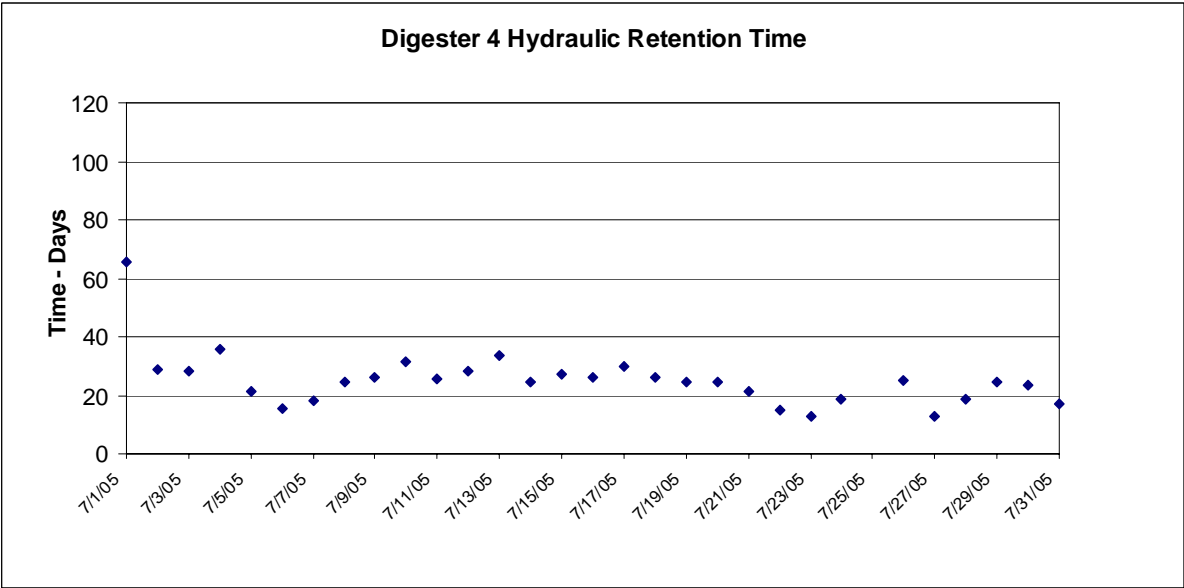


FIGURE 4-5
Digester 4 Hydraulic Retention Time

4.3 Digester 4 Performance

The digester stability indication parameters of pH and IA/PA, and the digester performance parameters of biogas production, VSR, and biogas yield are presented in Figures 4-6 through 4-10.

4.3.1 Digester 4 pH

Figure 4-6 shows Digester 4 pH during the month of July 2005.

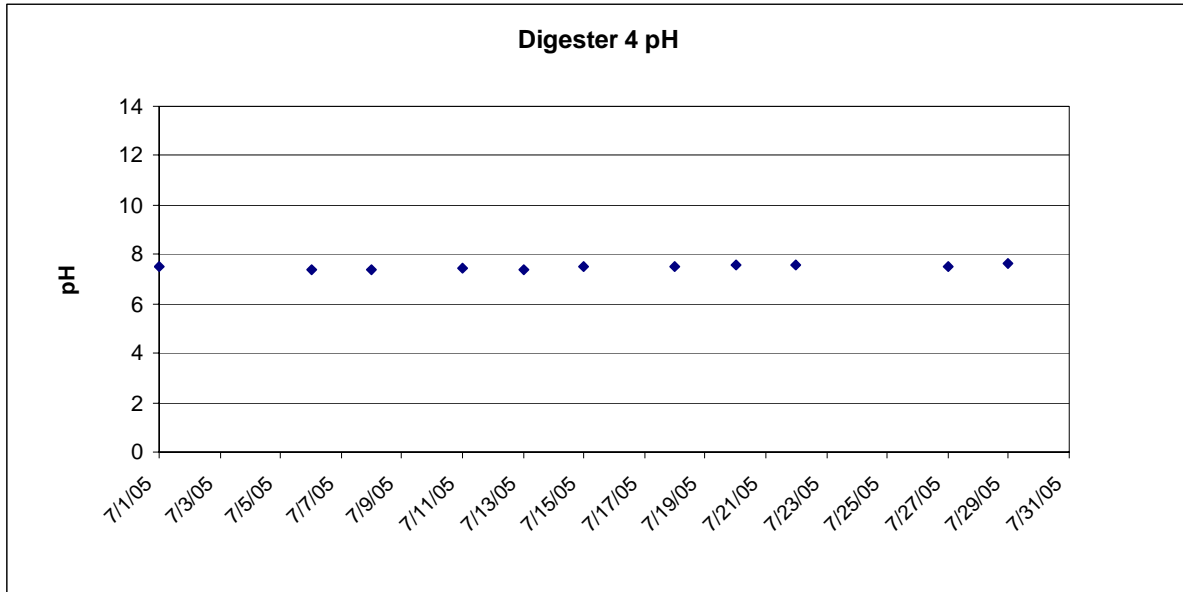


FIGURE 4-6
Digester 4 pH

4.3.2 Digester 4 IA/PA

Figure 4-7 shows Digester 4 IA/PA during the month of July 2005.

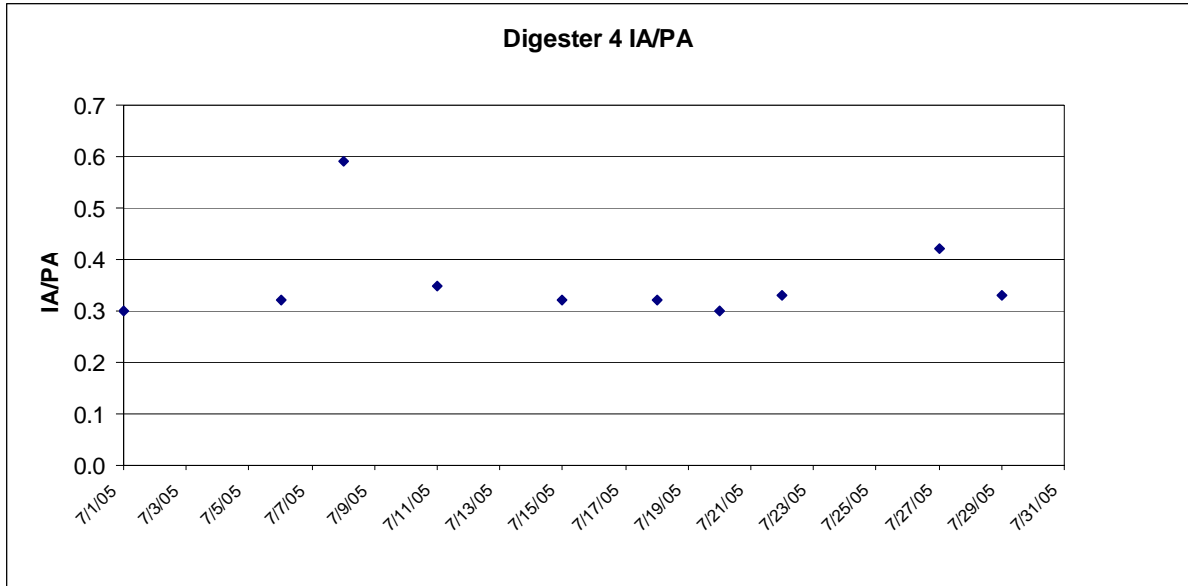


FIGURE 4-7
Digester 4 IA/PA

4.3.3 Digester 4 Temperature

Figure 4-8 shows Digester 4 temperature during the month of July 2005.

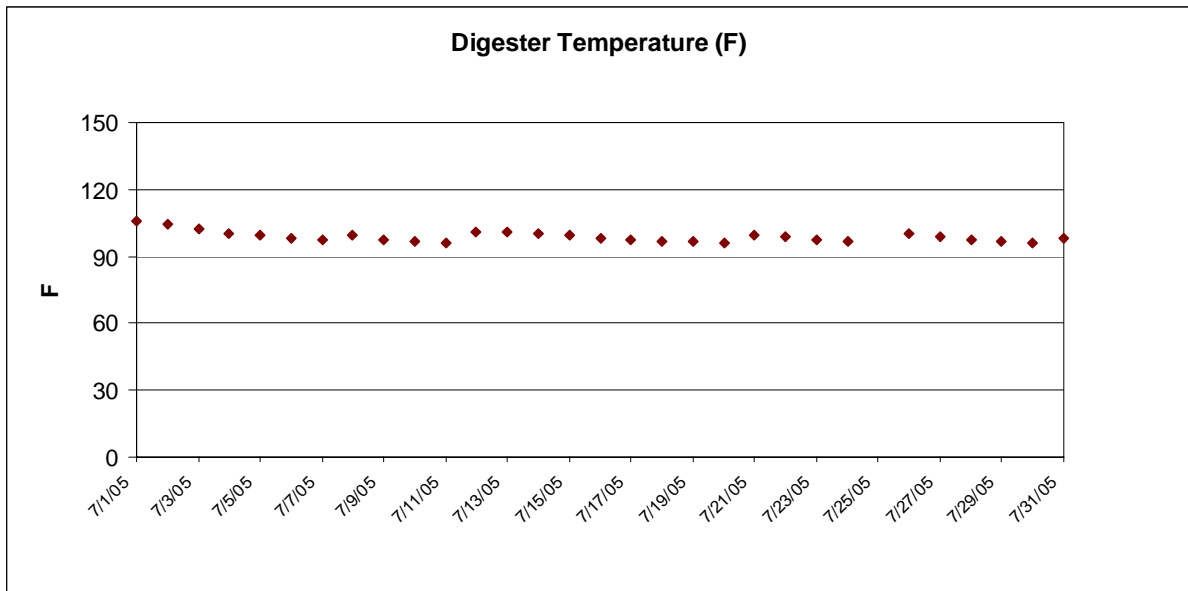


FIGURE 4-8
Digester 4 Temperature

4.3.4 Digester 4 Biogas Production

Figure 4-9 shows the daily biogas production by Digester 4 during the month of July 2005.

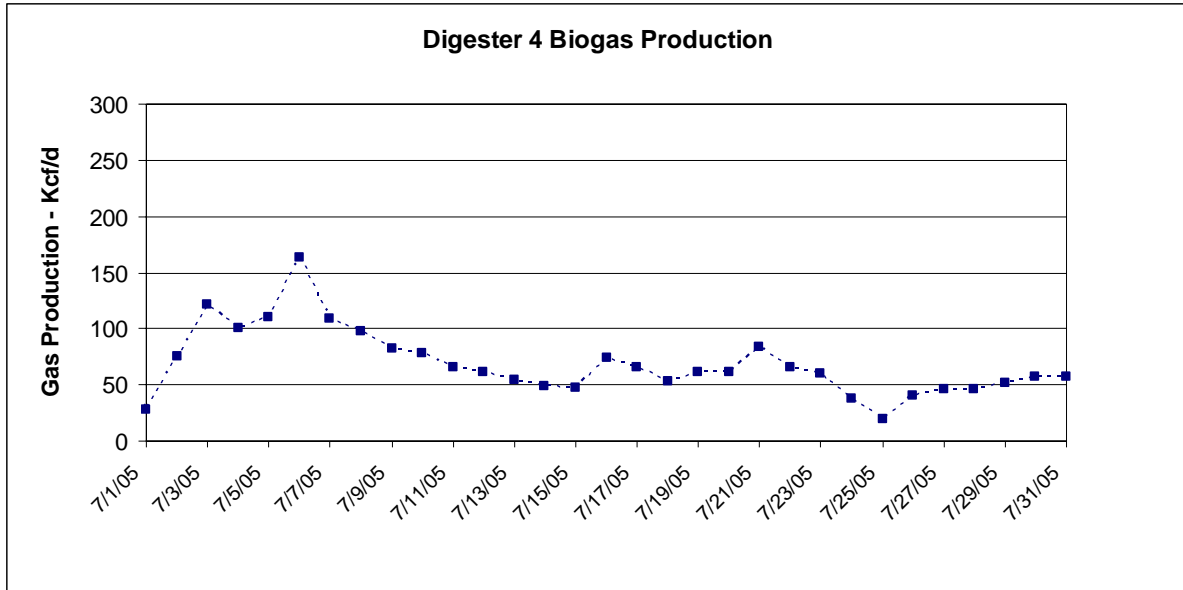


FIGURE 4-9
Digester 4 Gas Production

4.3.5 VSR

Figure 4-10 shows the percentage of VS reduction (VSR) in Digester 4 during the month of July 2005. VSR was calculated by using both the approximate mass balance and Van Kleeck methods, however, the approximate mass balance was considered more appropriate for this case and the result is presented here.

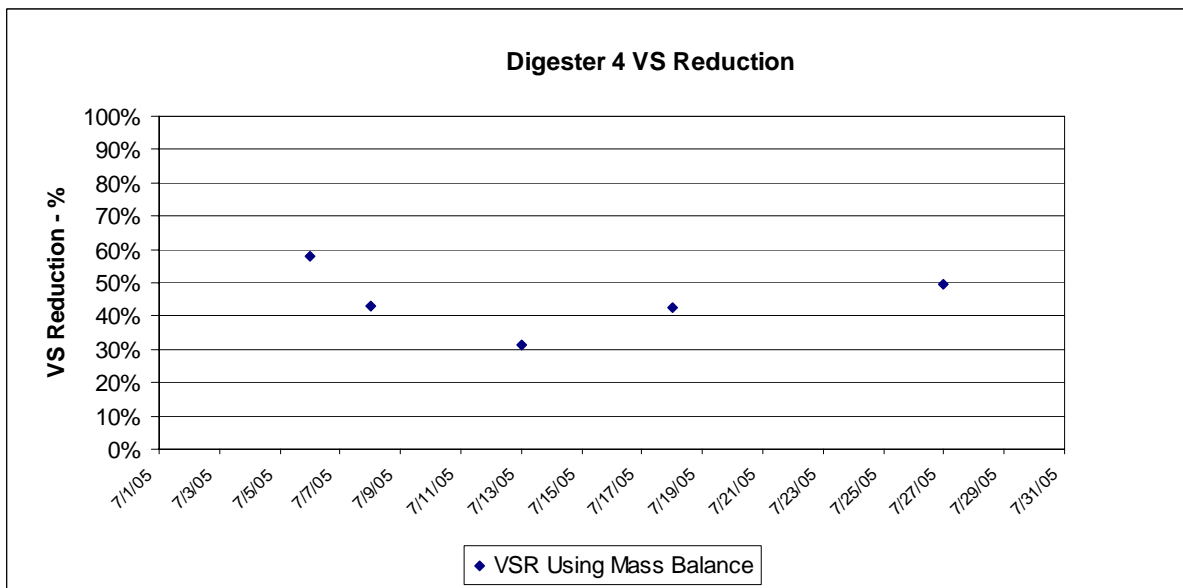


FIGURE 4-10
Digester 4 VS Reduction

4.3.6 Biogas Yield

Biogas yield is calculated as a ratio of biogas production to volatile solids reduction. Figure 4-11 shows the biogas yield obtained by Digester 4 during the month of July 2005.

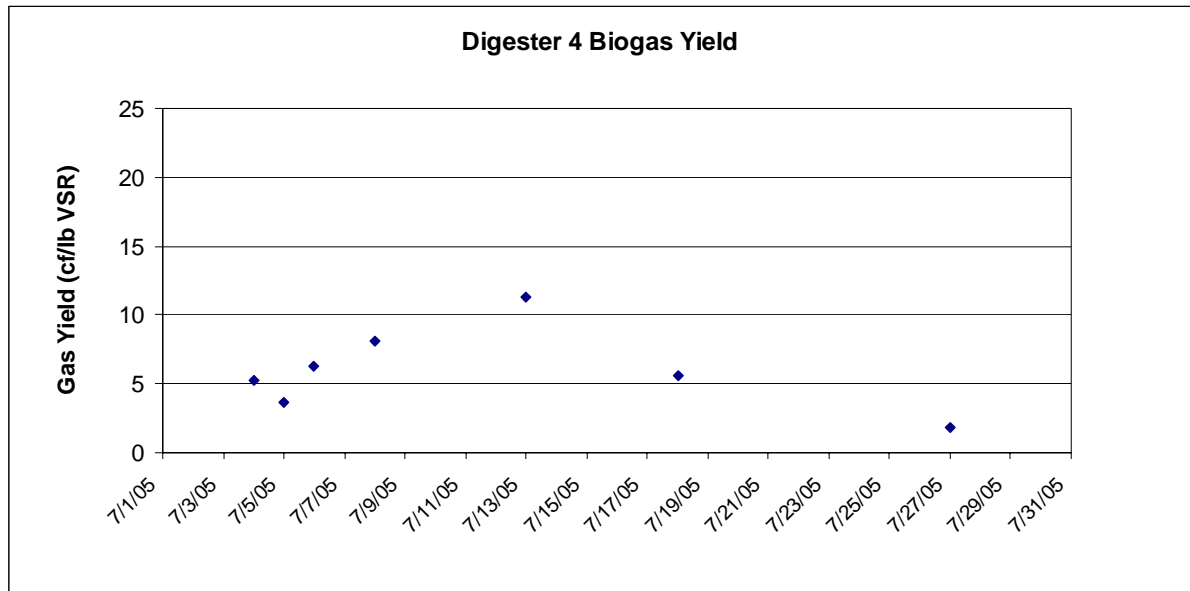


FIGURE 4-11
Digester 4 Biogas Yield

4.4 Monthly Operation and Performance Summary

Tables 4-2 and 4-3 provide the monthly averages for digester operational, performance, and dewatering data. Digester effluent characteristics such as solids concentrations and chemical data (e.g., alkalinity, ammonia and volatile acids) are also included. The flow and solids data were used to determine the mass balance and solids reduction in the digester. The chemical data are measures of digester stability (alkalinity, pH, VAs, ammonia). Ammonia and total Kjeldahl nitrogen (TKN) also have implications for the cost of filtrate treatment, and the fertilizer value of the biosolids product and sulfate concentrations can affect gas quality through H₂S formation. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H₂S concentrations.

TABLE 4-2
Monthly Digester 4 Data Averages for July 2005

Parameter	Units	July 2005
Digester Feed Characteristics		
Manure Flow	gpd	25,980
Food Waste flow ¹	gpd	1,070
Combined Flow	gpd	27,050
Manure TS	lb/d	33,230

TABLE 4-2
Monthly Digester 4 Data Averages for July 2005

Parameter	Units	July 2005
Manure VS	lb/d	26,720
Food Waste TS	lb/d	1,210
Food Waste VS	lb/d	1,100
Combined TS	lb/d	36,690
Combined VS	lb/d	29,920
Digester Effluent (i.e. Digested Manure and Food Waste Mixture)		
Digester TS	TS%	9.0
Digester VS	VS%	72
Digested TS	lb/d	21,370
Digested VS	lb/d	15,210
VSR	lb/d	15,410
VSR	%	45
pH	SU	7.5
Alkalinity	mg/L	9,604
VA	mg/L	1,050
VA:Alk (IA/PA)	-	0.36
Total Organic Carbon	mg/L	NA
COD	mg/L	NA
NH ₄ -N	mg/L	1,085
TKN	mg/L	3,264
Phosphate-P	mg/L	NA
Dissolved Sulfide	mg/L	NA
Total Sulfide	mg/L	NA
Total Sulfur	mg/L	NA
Total Sulfate	mg/L	NA
Proximate Analysis ²		NA
Digester Gas		
Gas	K cf/d	68
Gas Production	cf/lb VS in	3.3
Gas Yield	cf/lb VSR	6.0
CH ₄	%	56
CO ₂	%	34
H ₂ S	ppm	57
Volatile Sulfur Compounds	ppb	NA
Digester Operations		
Digester Temperature	°F	99

TABLE 4-2
Monthly Digester 4 Data Averages for July 2005

Parameter	Units	July 2005
Digester Free Board Level ³	ft	7.9
Digester Active Vol ⁴	gal	826,840
HRT by SWD Vol ⁴	days	25
VS Load Rate	lbVS/cf active volume ⁴	0.271
Iron Salt Addition	gpd	166

¹ Average food waste flow is the monthly average that includes the days without food waste delivery.

² Proximate Analysis

³ Digester Free Board Level is the actual operational level measured. Digester 4 side wall depth is 30 ft.

⁴ Digester's active volume (110,533 cf or 826,844 gal) was calculated based on digester SWD (30 ft) and with cone volume.

Flow, mass, and gas production data were rounded to the nearest 10.

NA: Not Available or Not Applicable

TABLE 4-3
Monthly Averages of Dewatering and Recycle Streams Data for Manure Digester 4 for July 2005

	Unit	July 2005
Feed to Dewatering		
pH	-	7.5
Alkalinity	mg/L	9,604
Temperature	°F	99
Flow	kgal/d	36
TS %	%	9.0
VS %	%	72
VA by IA/PA method	mg/L	1,050
NH ₄ -N	mg/L	1,085
COD	mg/L	NA
Magnesium	mg/L	NA
Ortho-phosphorus	mg/L	NA
Dissolved Sulfide	mg/L	NA
Total Sulfide		NA
Dewatered Cake		
TS %	%	30
Polymer usage	lb/ton	7.2

TABLE 4-3
Monthly Averages of Dewatering and Recycle Streams Data for Manure Digester 4 for July 2005

	Unit	July 2005
Filtrate		
pH	-	NA
Alkalinity	mg/L	NA
Flow	kgal/d	36
TDS	mg/L	10,910
TSS	mg/L	10,313
Dissolved Sulfide	mg/L	0.3
NH ₄ -N	mg/L	900
COD	mg/L	21,300
Magnesium	mg/L	NA
Ortho-phosphorus	mg/L	NA

NA: Not Available or Not Applicable

Biosolids and Food Waste Co-Digestion

5.1 Existing Biosolids Processing Trains at RP-1

RP-1 has six digesters for wastewater biosolids treatment. The solids from the primary clarifiers, or primary sludge, are thickened in a gravity thickener and the solids from the secondary clarifier, or waste activated sludge (WAS), are thickened with dissolved air flotation (DAF). The thickened primary sludge (TPS) and thickened WAS (TWAS) are then digested in a three-phase anaerobic digestion process: mesophilic acid phase digestion, followed by mesophilic and thermophilic gas phase digestion, then further digestion in an unheated gas phase. As shown in Figure 5-1, Digester 1 was used for the first acid phase, feeding Digester 2 (thermophilic), Digester 6 (mesophilic), and Digester 7 (thermophilic) as the second phase gas digesters. Digester 2 fed Digester 3 as the unheated gas digester. Digesters 6 and 7 fed Digester 5. Digester 5 was offline during the month of July for cleaning.

The digested biosolids are then dewatered by belt filter presses and hauled to the Agency's co-composting plant in Chino, operated by Synagro. Filtrate from the belt presses is sent to the non-reclaimable waste (NRW) line operated by the Los Angeles County Sanitation District. The digester gas is used in three Waukesha spark ignition lean burn engines and eight microturbines to generate electricity, and occasionally is used in two hot water boilers.

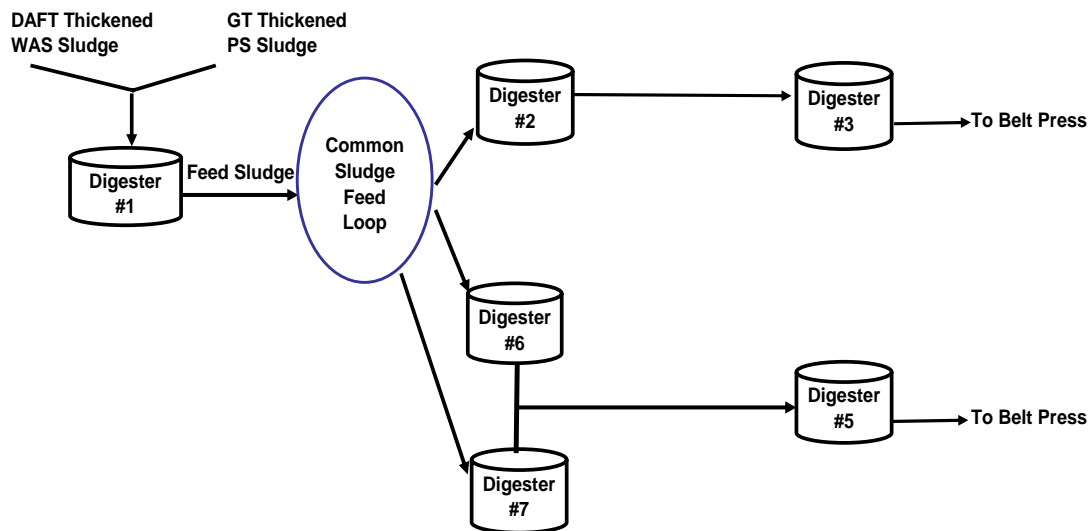


FIGURE 5-1
RP-1 Current Biosolids Digester Configuration

5.2 Biosolids and Food Waste Co-Digestion at RP-1

Beginning in early April 2005, the RP-1 plant initiated a co-digestion project. Food wastes are trucked to the plant on a daily basis and fed to DAFT 3, then to Digester 1, and on to the biosolids digestion trains. This section provides operational and performance data for the biosolids and food waste co-digestion obtained during the month of July 2005. The main focus is on Digester 2 and Digester 6, based on the co-digestion test plan, because these two digesters are operated at the thermophilic and mesophilic temperatures, respectively.

5.3 Digesters 2 and 6 Operational Parameters

Digester operational parameters, including feed characteristics, such as flow and solids concentrations to each digester, VS loading rate, and hydraulic retention time, are presented in Figures 5-2 through 5-5. Digester operational parameters affect digester performance; thus it is necessary to monitor these parameters in relation to digester performance.

5.3.1 Feed Biosolids and Food Waste

Figure 5-2 present the daily flow rate to Digester 2 (top) and Digester 6 (bottom). The flow represents the combined flow of the biosolids and food waste transferred to these digesters from the acid digester, Digester 1.

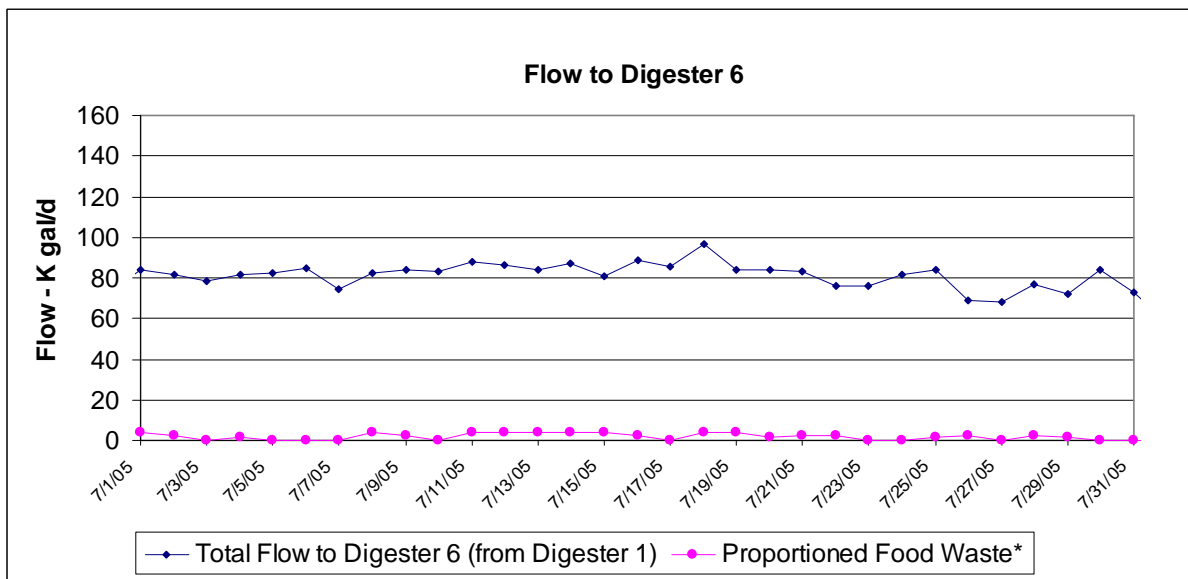
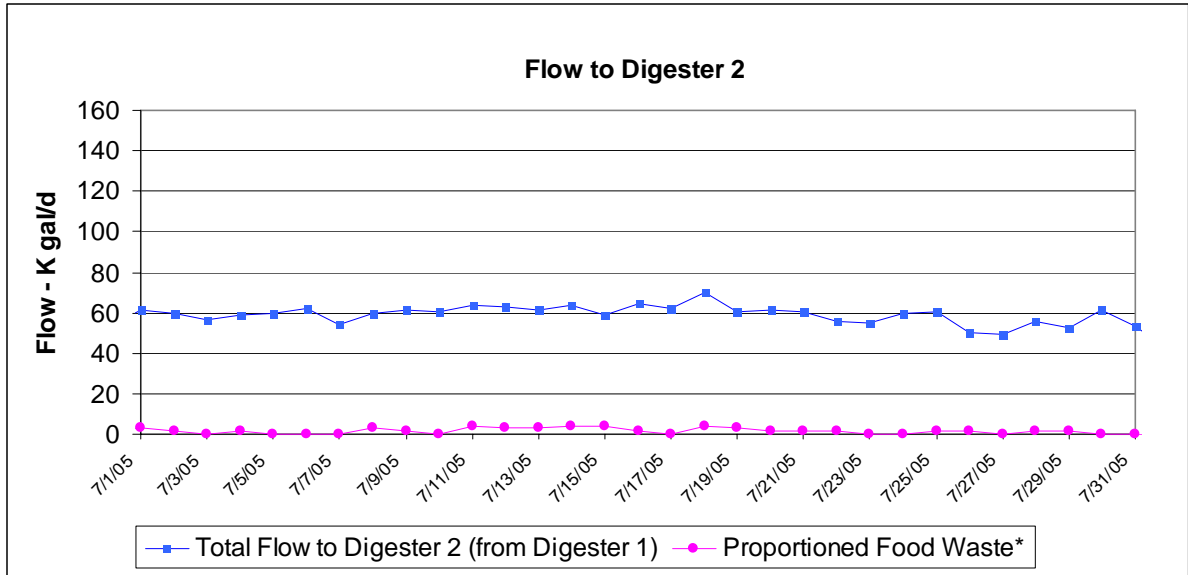


FIGURE 5-2
Biosolids and Food Waste Flow to Digester 2 and 6

* The food wastes flow to Digester 2 and 6 was the proportioned amount based on the total food waste fed to DAFT3 then Digester 1 for food waste and biosolids co-digestion test. This proportioned amount is included in the total flow fed to the digester as shown in the figures.

Figure 5-3 shows the feed TS concentration and VS content to Digesters 2 and 6 (i.e., Digester 1 effluent).

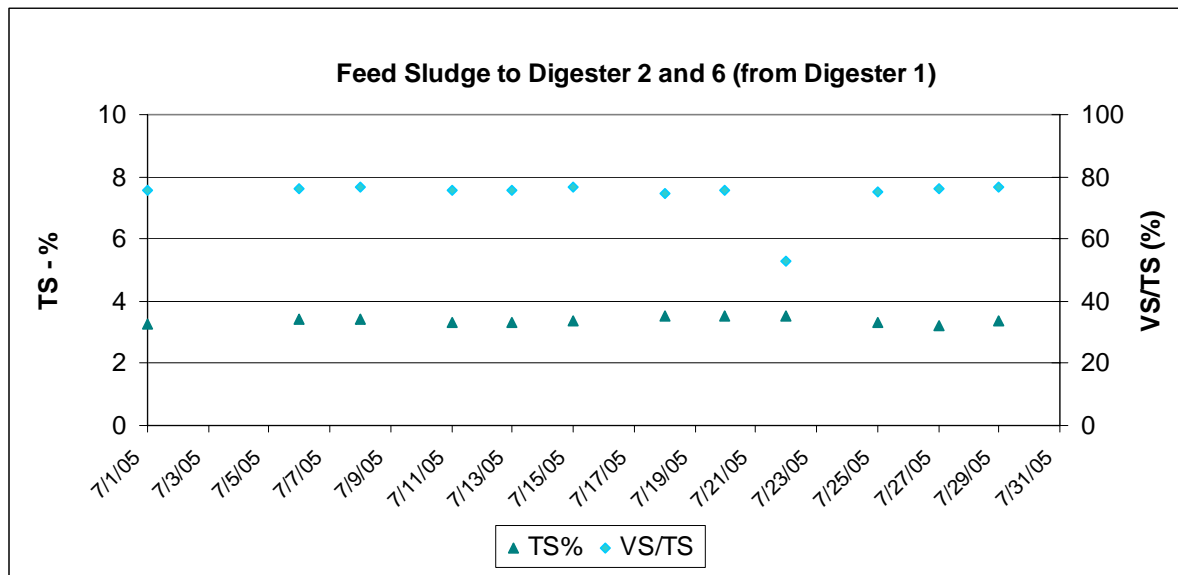


FIGURE 5-3
TS Concentration and VS Content of Digester 2 and 6 Feed Sludge (i.e. Digester 1 Effluent)

Table 5-1 shows the monthly feed characteristics averages for Digesters 2 and 6 for July 2005.

TABLE 5-1
Monthly Digester 2 and 6 Feed Characteristics Averages for July 2005

Parameter	Units	Biosolids & Food Waste Mixture Fed to Digester 2 & 6 (i.e. from Digester 1)	Food Waste Fed Directly to Digester 2	Food Waste Fed Directly to Digester 6
TS	%	3.4		
VS	%	74		
pH		5.3		
Alkalinity	mg/L	2,408		
Temperature	°F	98		
Volatile acids, mg/L	mg/L	3,871		
Total Organic Carbon	mg/L	NA		
COD	mg/L	NA		
NH ₄ -N	mg/L	403		
TKN	mg/L	2,254		
Proximate Analysis		NA		

NA: Not Available or Not Applicable

5.3.2 Solids Loading Rate (SLR)

Figure 5-4 shows the solids loading rate in Digesters 2 and 6.

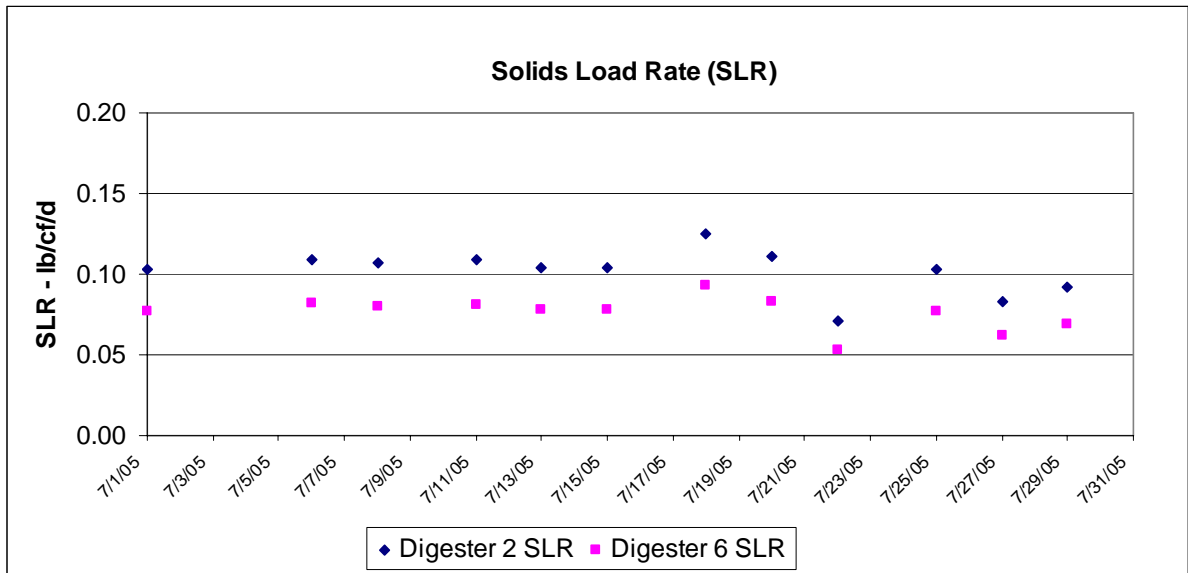


FIGURE 5-4
Digester 2 and 6 Volatile Solids Loading Rate

5.3.3 Hydraulic Retention Time (HRT)

Hydraulic retention times for both Digesters 2 and 6 are shown in Figure 5-5.

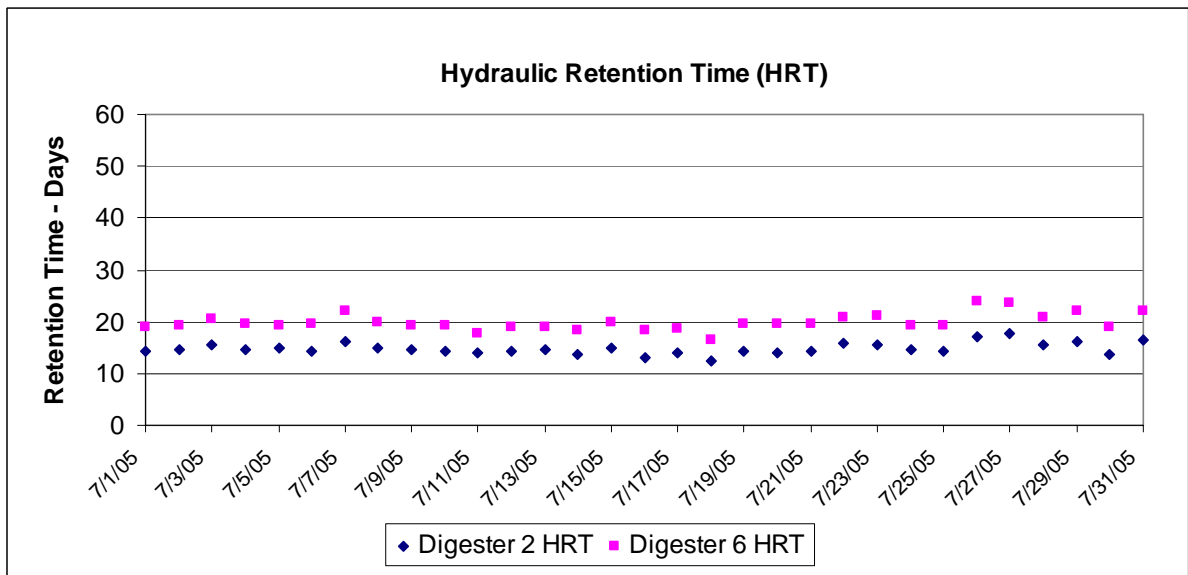


FIGURE 5-5
Digesters 2 and 6 Hydraulic Retention Times

5.4 Digesters 2 and 6 Performance

Digester stability indication parameters (pH and IA/PA) and digester performance parameters (biogas production, VSR, and biogas yield) are presented in Figures 5-6 through 5-11. The monthly averages of these data, along with digester feed, digested biosolids, and food waste mixture characteristics are discussed in Section 5.5.

5.4.1 Digester pH

The pH of Digester 2 and 6 is shown in Figure 5-6.

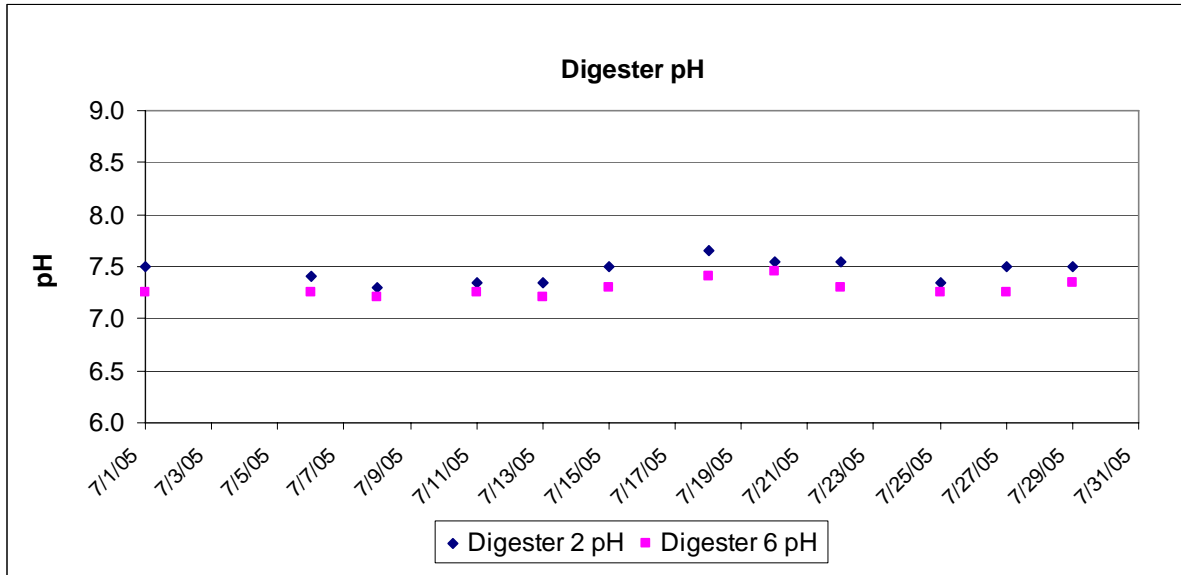


FIGURE 5-6
Digester pH

5.4.2 Digester IA/PA

Digester 2 and 6 IA/PA is presented in Figure 5-7.

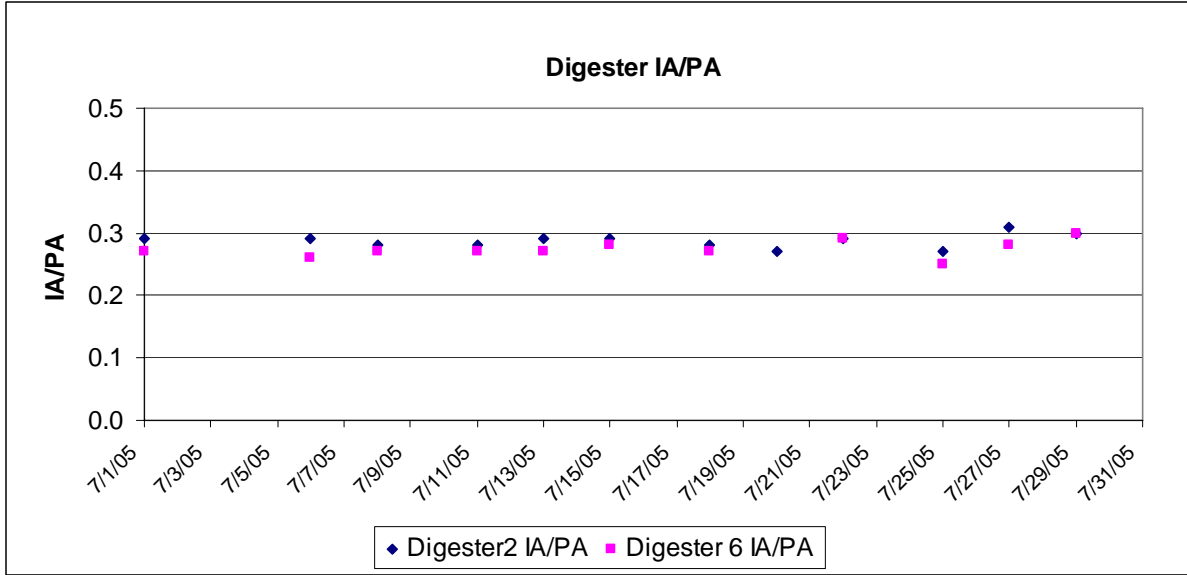


FIGURE 5-7
Digester IA/PA

5.4.3 Digester Temperature

Digester 2 and 6 temperature is presented in Figure 5-8.

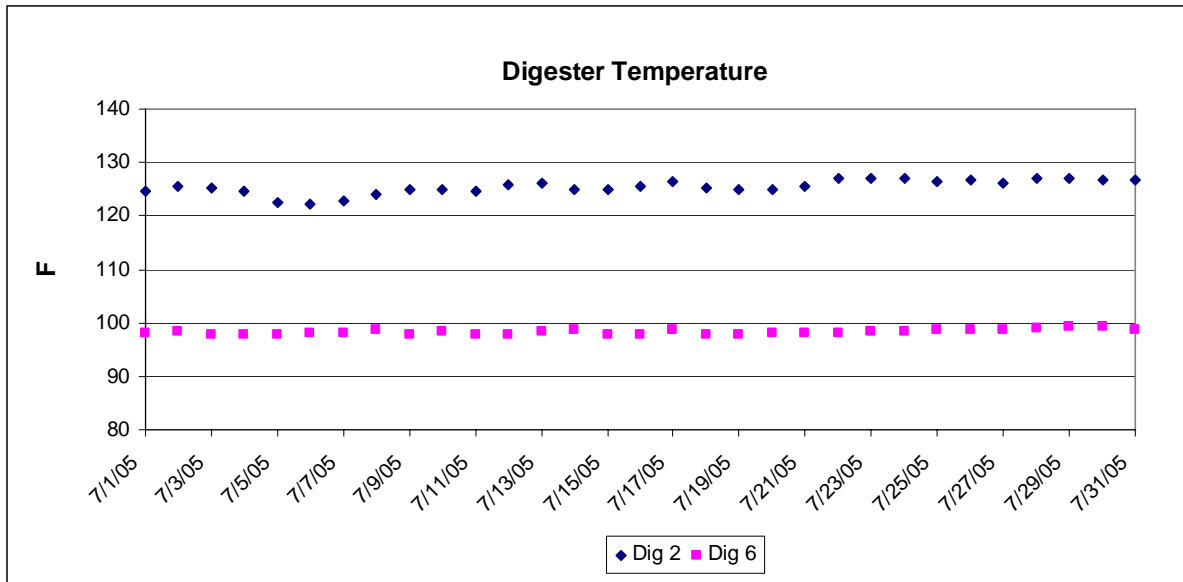


FIGURE 5-8
Digester Temperature

5.4.4 Biogas Production

Figure 5-9 shows the daily gas production by Digester 2 and 6.

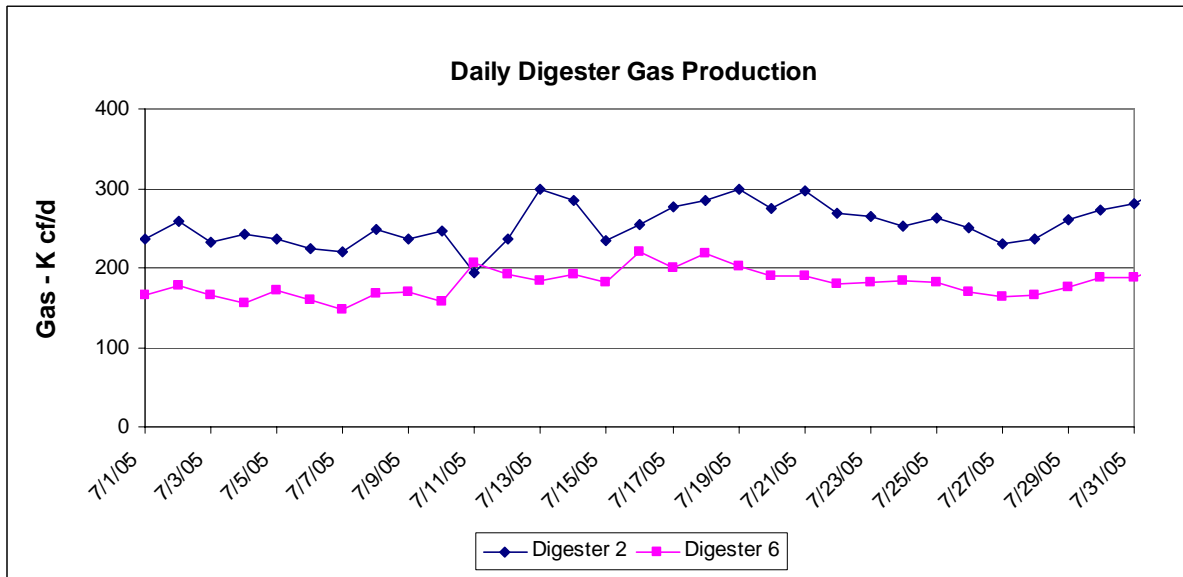


FIGURE 5-9
Digester Gas Production

5.4.5 VSR

Figure 5-10 shows VS reduction in Digesters 2 and 6. Approximate mass balance method was used for calculating the VSR.

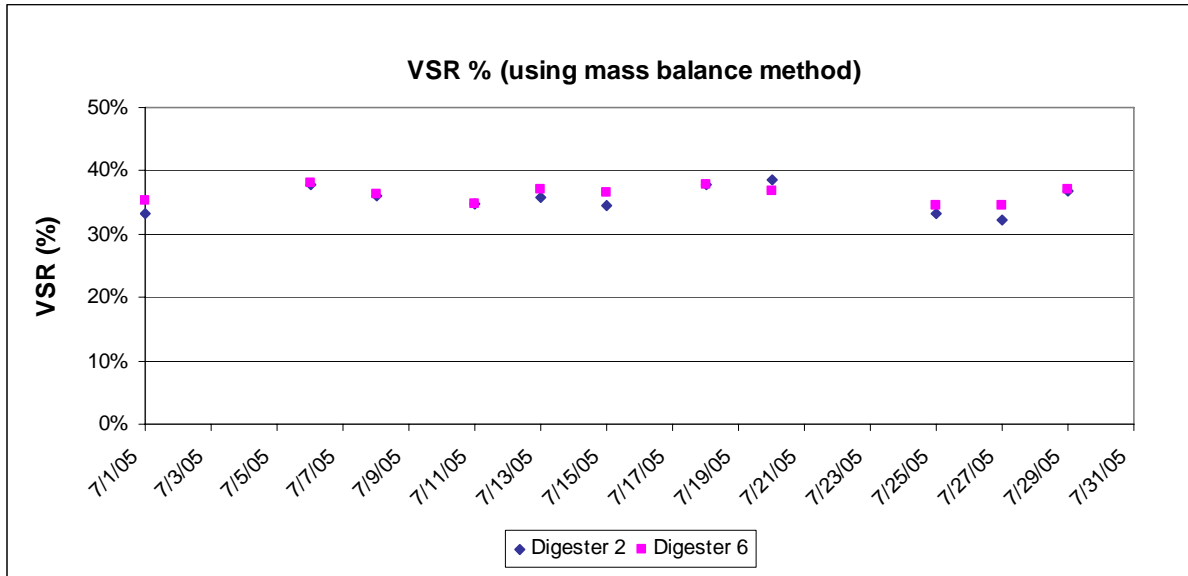


FIGURE 5-10
VS Reduction

5.4.6 Biogas Yield

Figure 5-11 shows the biogas yield by Digesters 2 and 6.

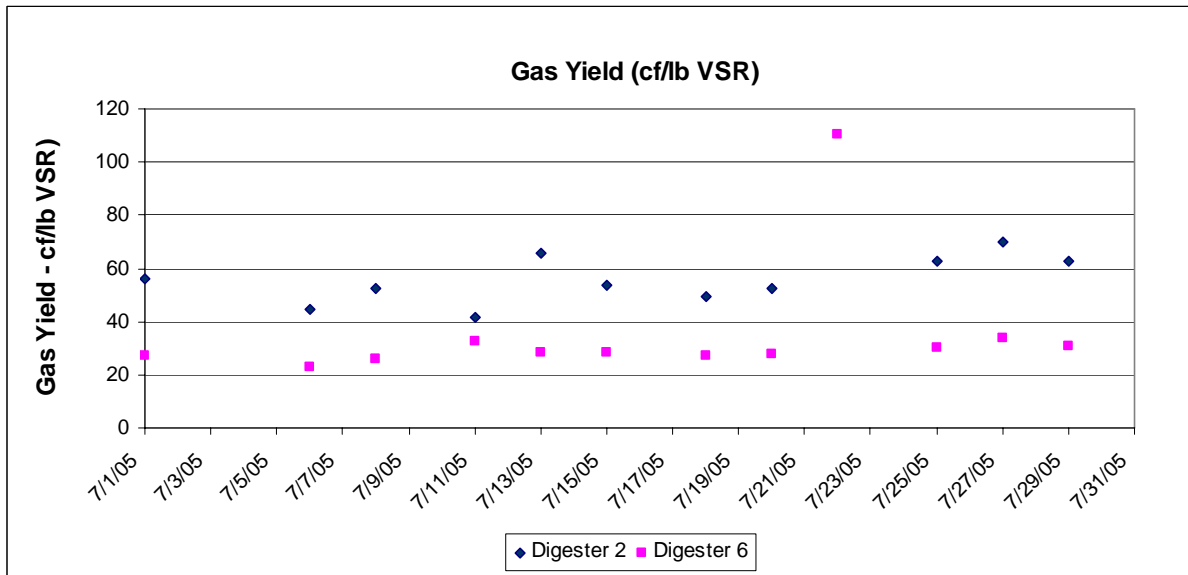


FIGURE 5-11
Biogas Yield

5.5 Monthly Operation and Performance Summary

Tables 5-2 and 5-3 provide the monthly average data for digester operation, performance, and dewatering. Digester effluent characteristics, such as solids concentrations and chemical data (e.g., alkalinity, ammonia and volatile acids), are also included. The flow and solids data were used to determine the mass balance and solids reduction in the digester. The chemical data are measures of digester stability (alkalinity, pH, VA, ammonia). Ammonia and TKN also have implications for the cost of filtrate treatment. In addition, the fertilizer value of the biosolids product and sulfate concentrations can affect gas quality through formation of H₂S. The digester gas data are also presented, including total gas produced and gas yield. Gas quality parameters include methane content and H₂S concentrations. The methane content was calculated based on carbon dioxide content measured in the gas.

TABLE 5-2
Monthly Averages of Digester 2 and 6 Operational and performance Data for July 2005

Parameter	Units	Digester 2	Digester 6
Digester Feed Characteristics			
Mixture of Combined Biosolids and Food Waste Flow from Digester 1	gpd	59,250	81,460
Proportioned Food Waste Flow ¹	gpd	1,610	1,880
Combined TS	lb/d	16,820	23,120
Combined VS	lb/d	12,440	17,100
Digested Sludge			
Dig Sludge TS	TS%	2.5	2.5
Dig Sludge VS	VS%	66	66
Dig Sludge TS	lb/d	12,370	16,920
Dig Sludge VS	lb/d	8,190	11,110
VSR	lb/d	4,560	6,380
VSR	%	36	36
pH	SU	7.5	7.3
Alkalinity	mg/L	3,893	3,807
VA	mg/L	391	160
VA:Alk (IA/PA)	-	0.3	0.4
Total Organic Carbon	mg/L	NA	NA
COD	mg/L	NA	NA
NH ₄ -N	mg/L	985	1,015
TKN	mg/L	2,169	2,119
Phosphate-P	mg/L	NA	NA
Dissolved Sulfide	mg/L	NA	NA
Total Sulfide	mg/L	NA	NA
Total Sulfur	mg/L	NA	NA
Total Sulfate	mg/L	NA	NA
Proximate Analysis		NA	NA
Digester Gas			
Gas	kcf/d	255	180

TABLE 5-2
Monthly Averages of Digester 2 and 6 Operational and performance Data for July 2005

Parameter	Units	Digester 2	Digester 6
Gas Yield	cf/lb VSR	56	29
CH ₄	%	NA	NA
CO ₂	%	NA	NA
H ₂ S	ppm	NA	NA
Volatile Sulfur Compounds	ppb	NA	NA
Digester Operations			
Digester Temperature	°F	125	98
Digester Free Board Level ²	ft	1.6	1.5
Digester active vol ³	gal	916,270	1,680,630
HRT by SWD vol	days	15	20
VS load rate	lbVS/cf active volume ³	0.102	0.076

¹ Food waste was added to Digester 1 from DAFT3. The flow here is the proportioned amount based on the flow distribution ratio from Digester 1 to Digesters 2, 6 and 7. Average number includes zeros.

² Digester Free Board Level is the actual operational level measured. Digesters 2 and 6 side wall depths are 30 ft.

³ Digester's active volume was calculated based on digester SWD (30 ft) and with cone volume.

Flow, mass and gas production data were rounded to the nearest 10.

NA: Not Available or Not Applicable

TABLE 5-3
Monthly Averages of Dewatering and Recycle Streams Data for Digester 2 and 6 for July 2005

	Unit	Digester 2	Digester 6
Feed to Dewatering			
pH	-	7.5	7.3
Alkalinity	mg/L	3,893	3,807
Temperature	°F	125	98
TS %	%	2.5	2.5
VS %	% of TS	66	66
VA by IA/PA method	mg/L	392	160
NH ₄ -N	mg/L	985	1,015
COD	mg/L	NA	NA
Magnesium	mg/L	NA	NA
Ortho-phosphorus	mg/L	NA	NA
Dissolved Sulfide	mg/L	NA	NA
Total Sulfide	mg/L	NA	NA
Dewatered Cake			
TS %	%	17 ¹	
Polymer usage	lb/ton	15 ¹	

TABLE 5-3
Monthly Averages of Dewatering and Recycle Streams Data for Digester 2 and 6 for July 2005

	Unit	Digester 2	Digester 6
Filtrate			
pH	-		NA ¹
Alkalinity	mg/L		NA ¹
TDS	mg/L		1,340 ¹
TSS	mg/L		310 ¹
Dissolved Sulfide	mg/L		<0.1 ¹
NH ₄ -N	mg/L		804 ¹
COD	mg/L		1,160 ¹
Magnesium	mg/L		NA ¹
Ortho-phosphorus	mg/L		NA ¹

¹ The numbers are tracked for the combined filtrate from dewatering of the biosolids digesters currently.

NA: Not Available or Not Applicable