Class A Biosolids

Hyperion Treatment Plant (Phase IV)

Wastewater Eng. Services Division (Applied Research)

Hyperion Treatment Plant

Terminal Island Treatment Plant

Environmental Monitoring Division

Regulatory Affairs Division

Environmental Engineering Division

Human Resources Development Division

City of Los Angeles
Bureaus of Sanitation and Engineering

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EXECUTIVE SUMMARY

Phase IV testing at Hyperion Treatment Plant (HTP) (October 2002) demonstrated meeting the 40 CFR Part 503 Alternative 1 Class A pathogen requirements in a two-stage batch process. This process was used for the treatment of HTP's total feed sludge of on average 3.0 mgd primary sludge and 0.8 mgd thickened waste activated sludge and consisted of:

1. A thermophilic first stage of 16 digesters that were operated in a continuous mode at an average temperature of 135.5 ^{0}F and a hydraulic retention time of about 10.5 days.
2. A thermophilic second stage of 4 digesters that were operated in a batch mode to comply with the time-temperature requirement of Alternative 1. The guaranteed holding time was 16 hours, which required a treatment temperature of 133.3 ^{0}F.

During the period of October 7 – 24, 2002, daily testing was performed with the following results:

1. The lowest temperature recorded by continuous monitoring by the Control Room during batch holding in any of the four second stage digesters over the testing period was 133.8^{0}F.
2. Fecal coliforms in farm biosolids were below the Class A limit in all of 10 daily samples.
3. No difference was found for the number of fecal coliforms in farm biosolids if the biosolids were transported in designated, steam-cleaned trucks or in regular trucks.
4. *Salmonella* sp. in farm biosolids were below the Class A limit in all of 10 daily samples.
5. Helminth ova were below the Class A limit in composited samples of farm biosolids.
6. Enteric viruses were below the Class A limit in composited samples of farm biosolids.

The conclusion of Phase IV testing is that full compliance with the Class A requirements of 40 CFR 503.32 is achieved, both regarding the time-temperature requirement for batch treatment as specified in Alternative 1 and the general requirement for densities of fecal coliforms and *Salmonella* sp. in biosolids at the farm.

Though not required for Alternative 1 in 40 CFR 503, it has also been demonstrated that the Phase IV process completely destroyed enteric viruses, whereas helminth ova were not detected in the untreated sludge and farm biosolids.

1. INTRODUCTION

In the first week of October, 2002, the conversion of the Hyperion Treatment Plant (HTP) to a two-stage batch process for Class A biosolids production by thermophilic anaerobic digestion was completed. The objective was to produce Class A biosolids using the time-temperature requirement for batch treatment as specified in Alternative 1 of 40 CFR Part 503.32.

This report summarizes the results of Phase IV testing at HTP, which were conducted from October 7 to 10, 2002. The specific objectives of Phase IV were:

1. Demonstration of compliance with the time-temperature requirement for batch treatment in Alternative 1 of 40 CFR 503.32.
2. Demonstration of compliance with the Class A limits for fecal coliforms and *Salmonella* sp. in biosolids at the farm.
3. Demonstration of complete destruction of non-bacterial pathogens (viable helminth ova and enteric viruses) in biosolids.

Although Aternative 1 requires compliance with the Class A limit for fecal coliforms or *Salmonella* sp., both were tested to show compliance with Kern County requirements. Similarly, destruction of viable helminth ova and enteric viruses does not need to be demonstrated when using Alternative 1. This was included to provide additional evidence of the ability of the HTP Phase IV process to also provide complete disinfection of non-bacterial pathogens.

2. MATERIALS AND METHODS

Process description: Full conversion of HTP to a two-stage batch process was completed in the first week of October 2002. The total plant's feed sludge of an average of 3.0 mgd primary sludge and 0.8 mgd thickened waste activated sludge was treated in 20 egg-shaped digesters, each with a volume of 2.5 million gallons and an internal draft system for mixing. **Figure 1** presents a schematic of the digestion process. The first stage contained 16 digesters from Batteries D1, D2 and E, which were all operated in a continuous mode. Four digesters in Battery E were used for second stage batch digestion according to the feed/hold/withdraw cycles (8, 16, and 8 hours, respectively) presented in **Figure 2**. The average hydraulic retention time in the first stage was about 10.5 days, whereas the guaranteed holding time in the second stage was 16 hours. First stage digesters were heated by steam injection into the digester sludge feed lines and into the top of the digesters. Additional steam supply was into the sludge transfer lines from the first to the second stage digesters.

Digester temperatures: Temperatures in the digesters were continuously recorded by the Control Room. **Table 1** presents the minimum temperature observed during holding in each of the four second stage digesters. Between October 11 and 25, 2002, the lowest temperature was 133.8^0F in Digester 7E (October 11, 2002). This temperature is still above the minimum of 133.3^0F required for a holding period of 16 hours. **Figure 3** provides examples that demonstrate that the second stage digester temperatures were relatively constant during holding. The batch digester typically cooled down by 0.4 degree during a 16 hour holding cycle. It can therefore be assumed that average and maximum temperatures during were respectively 0.2 and 0.4 degrees above the minimums provided in **Table 1**.

Temperatures in first stage digesters are summarized in **Table 2**. The overall average was 135.5^0F (range of 131.0 to 140.6^0F).

Sampling and analytical procedures: Phase IV testing covered three weeks of sampling (October 7 to 24, 2002) as shown in **Table 3**. Samples were taken from primary sludge and farm biosolids and analyzed for fecal coliforms, *Salmonella* sp. and total solids by the Environmental Monitoring Division at HTP. Composite samples of primary sludge and farm biosolids were taken for the analysis of viable helminth ova and enteric viruses by BioVir Laboratories, Benicia, CA. Temperatures in farm biosolids were measured with a digital thermometer in the total solids sample immediately after collection. All analytical procedures were according to the EPA requirements in 40 CFR 503, as summarized in **Table 4**.

Farm biosolids were usually collected from a designated truck that was cleaned by steam before loading from the silos at the Truck Loading Facility. During the third week of Phase IV testing, parallel samples at the farm were taken from a non-designated truck in order to determine whether steam-cleaning of trucks would have an effect on the biosolids quality at the farm.

3. RESULTS

All results are summarized in **Table 5**.

Fecal coliform densities in primary sludge were not determined during Phase IV, however, form earlier measurements during Phases I and II, it could be assumed that these were in the order of 10^7 - 10^8 MPN/g dry wt. Complete disinfection regarding fecal coliforms was observed in the Phase IV process. Fecal coliforms were <7 MPN/g dry wt in all of the 10 biosolids samples taken at the farm. This would imply that the HTP process reduces the number of fecal coliforms by an order of magnitude of 6 or higher, and that the final density in biosolids at the farm is at least 100 times less than the Class A limit of 1000 MPN/g dry wt.

Salmonella sp. densities in primary sludge varied between <1.9 to 15 MPN/4 g dry wt. *Salmonella* sp. were <1.5 MPN/g dry wt in all of 10 farm samples taken over 2 weeks, and therefore compliance with the Class A standard for *Salmonella* sp. was met at all times.

Parallel sampling from designated and non-designated trucks was conducted in the final week of Phase IV testing. The results in **Table 5** demonstrate that fecal coliforms and *Salmonella* sp. were non-detect regardless of the truck used for transport to the farm.

Biosolids temperatures at the farm were on average 129.4^{0}F (range 127.7 to 131.6^{0}F). temperatures of in the low 50s (**Table 5**). The difference in temperature between farm biosolids and sludge in the batch digesters was around 4.9^{0}C, as calculated from average temperatures.

4. CONCLUSIONS

The Phase IV two-stage batch process at HTP fully complies with Alternative 1 of 40 CFR 503.32 for Class A biosolids, because:

1. The time/temperature requirement for batch treatment (16 hours / 133.3^{0}F) was met by providing a guaranteed holding period of 16 hours at a temperature of 133.8^{0}F or higher.
2. Farm biosolids consistently complied with the Class A limits for fecal coliforms and *Salmonella* sp.

In addition, compliance with the Class A limits for helminth ova and enteric viruses was demonstrated in farm biosolids, although this not required for Alternative 1 of 40 CFR 503.

Full compliance with all Class A standards for farm biosolids can be attributed to:

1. A time/temperature treatment that exceeds the minimal requirements of Alternative 1 in 40 CFR 503.32.
2. Absence of contamination of thermophic sludge with mesophilic sludge now that HTP is fully converted to thermophilic treatment.
3. Insulation of the post-digestion train that prevents excessive cooling of biosolids after the digesters.

5. REFERENCES

APHA (1992). Standard methods for the examination of water and wastewater. 18th edition, American Public Health Association, Washington, D.C.

ASTM (1992). Standard Practice for recovery of viruses from wastewater sludges. Annual Book of ASTM Standards: Section 11 – Water and Environment Technology, ASTM, Philadelphia, PA.

Kenner, B.A., Clark, H.P. (1974). Detection and enumeration of *Salmonella* and *Pseudomonas aeruginosa*. J. Water Pollution Control Federation 46(9):2163-2171.

U.S. EPA (1987). Occurrence of pathogens in distribution and marketing municipal sludges. EPA 600/1-87-014.

U.S. EPA (1999). Environmental regulations and Technology, Control of Pathogens and Vector Attraction in Sewage Sludge. EPA/625/R92/014.

Figure 1. Schematic of thermophilic digester operations at HTP during Phase IV tests

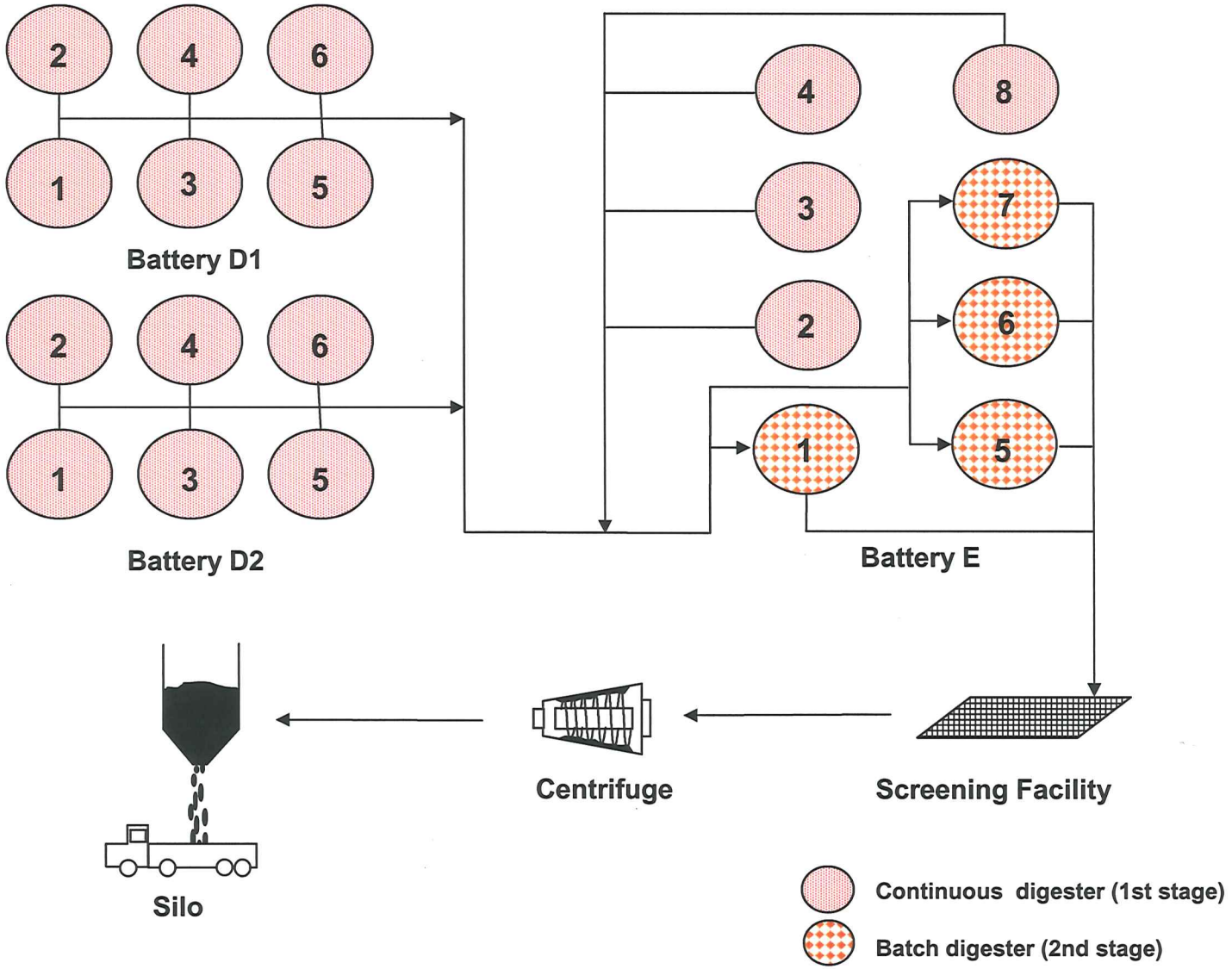

Figure 2. Feed/hold/withdraw cycles for stage 2 batch digesters

	8 hr	8 hr	8 hr	8 hr	8 hr
	Sequece #1	Sequece #2	Sequece #3	Sequece #4	Sequece #1
1E	Feed	Hold	Hold	Withdraw	Feed
5E	Withdraw	Feed	Hold	Hold	Withdraw
6E	Hold	Wihdraw	Feed	Hold	Hold
7E	Hold	Hold	Withdraw	Feed	Hold

Note

1. Target temp. according to Alternative 1 time temp. formula 3 is 133.3 °F

Figure 3a. Example of batch digester temperatures over time

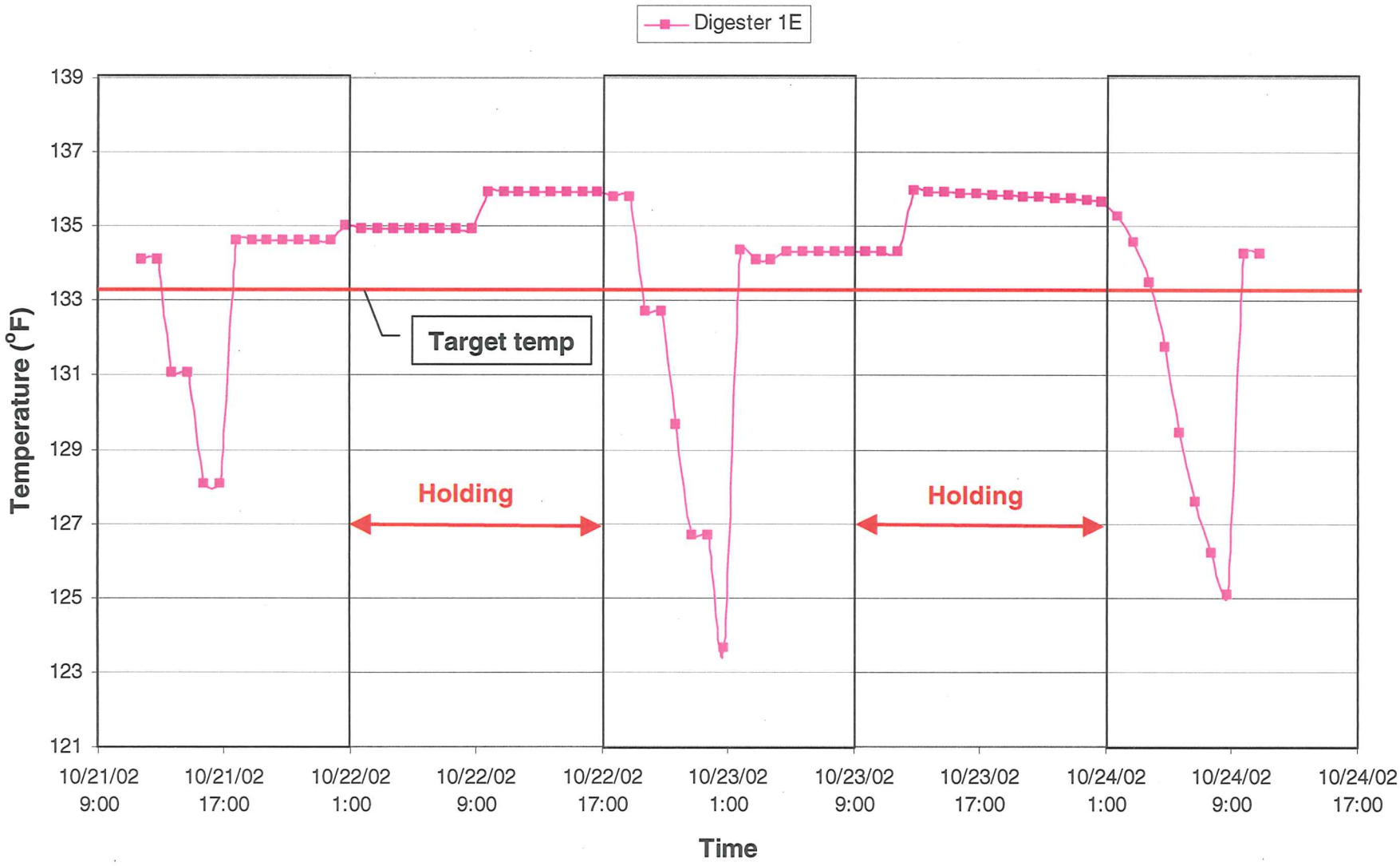

Figure 3b. Example of batch digester temperatures over time

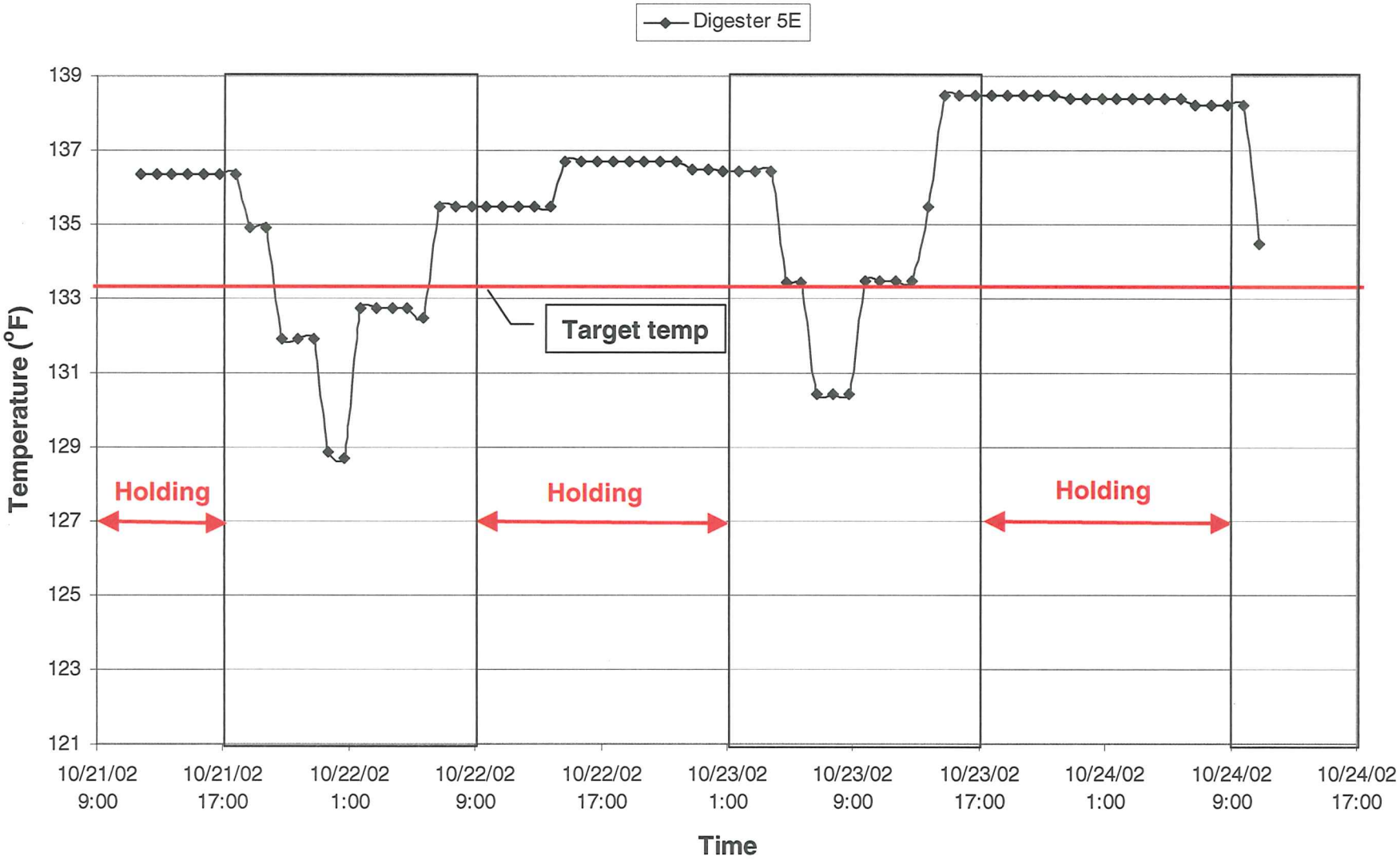

Figure 3c. Example of batch digester temperatures over time

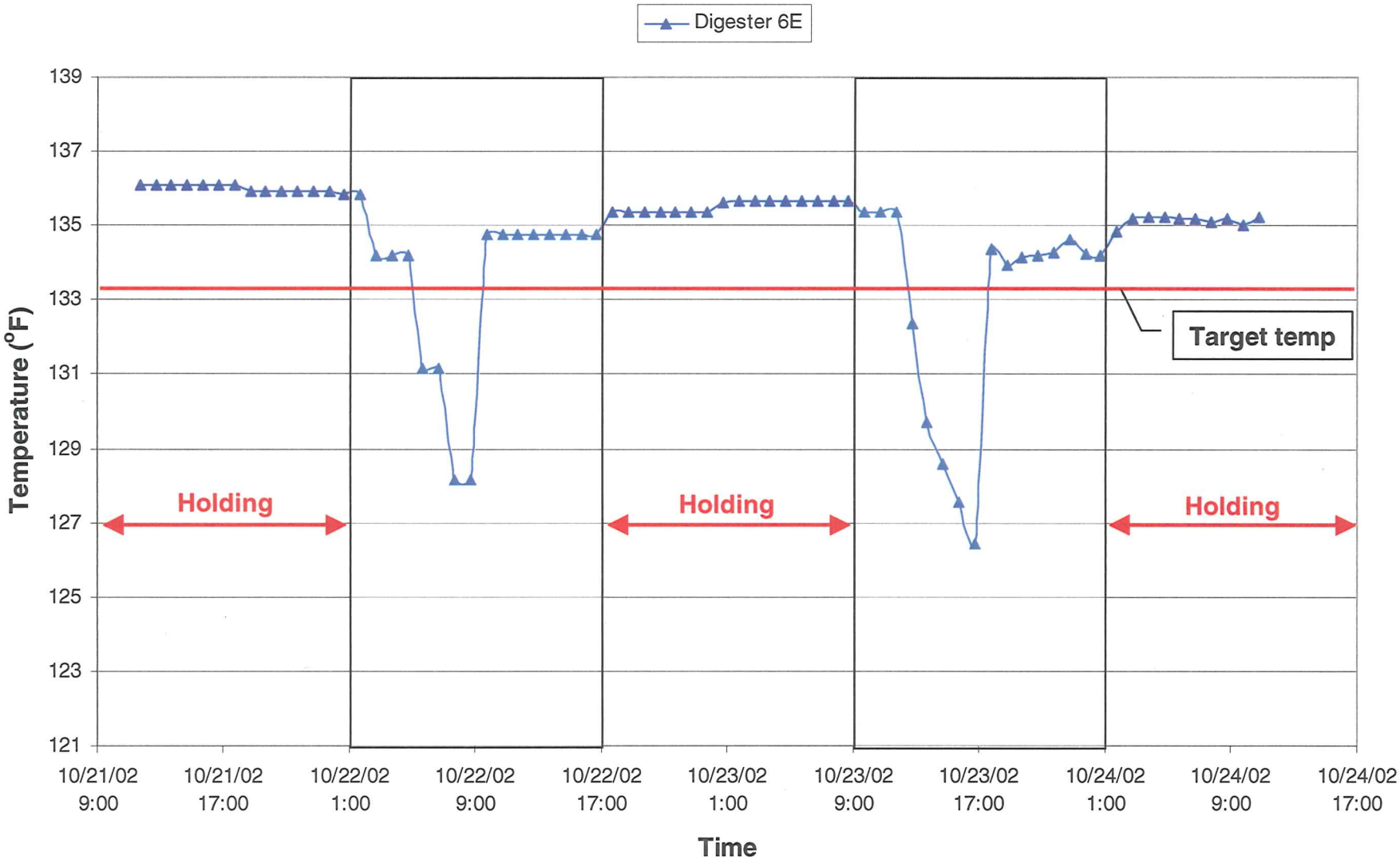

Figure 3d. Example of batch digester temperatures over time

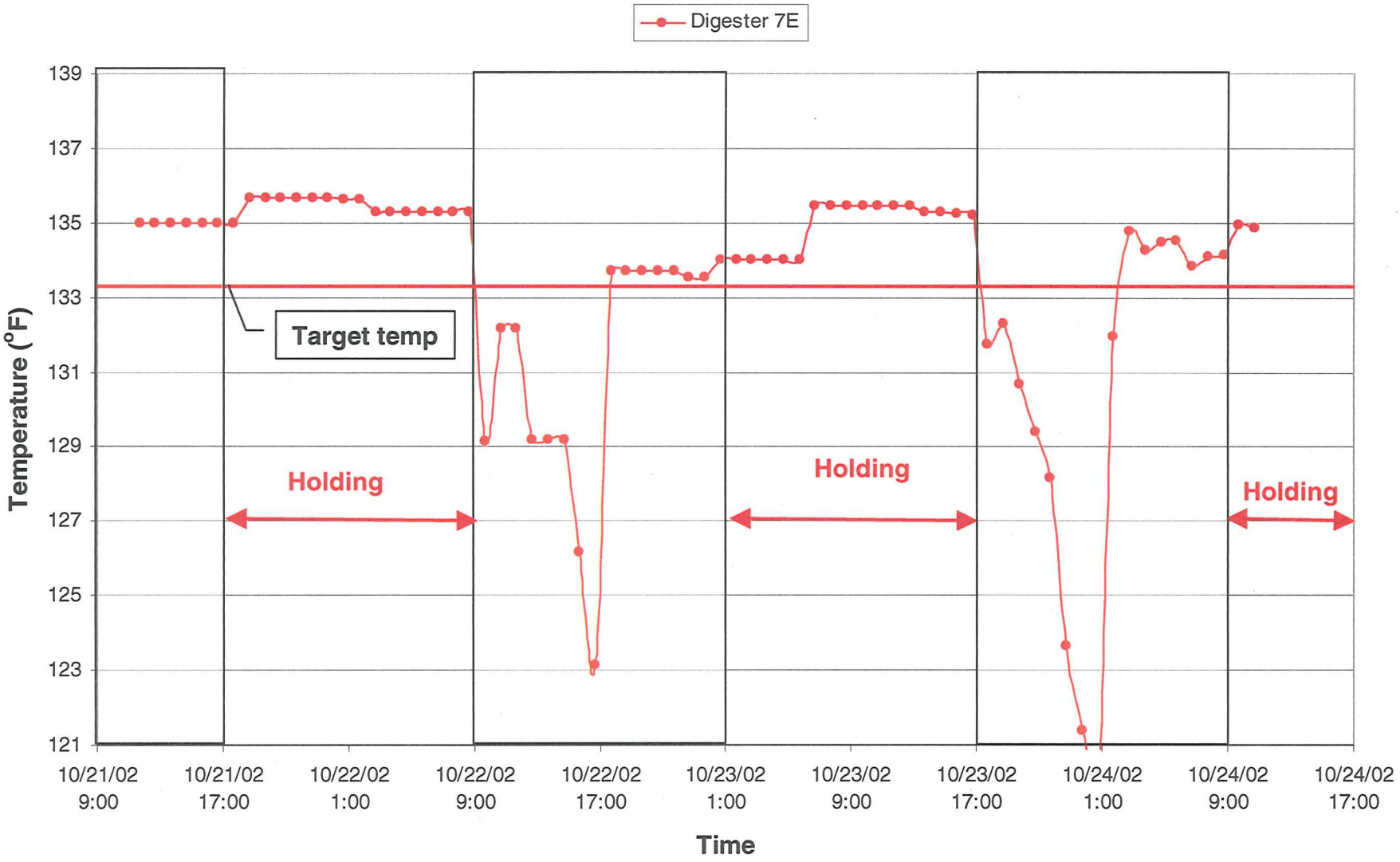

Table 1. Batch Digester Minimum Temperatures

Date	Time	Sequence	Tank started discharging	Lowest batch Temperature
10/11/02	1:00 AM	1	5E	134.8
10/11/02	9:00 AM	2	6E	134.1
10/11/02	5:00 PM	3	7E	133.8
10/12/02	1:00 AM	4	1E	135.1
10/12/02	9:00 AM	1	5E	136.0
10/12/02	5:00 PM	2	6E	135.5
10/13/02	1:00 AM	3	7E	135.0
10/13/02	9:00 AM	4	1E	136.2
10/13/02	5:00 PM	1	5E	136.4
10/14/02	1:00 AM	2	6E	135.7
10/14/02	9:00 AM	3	7E	135.0
10/14/02	5:00 PM	4	1E	136.4
10/15/02	1:00 AM	1	5E	136.0
10/15/02	9:00 AM	2	6E	134.7
10/15/02	5:00 PM	3	7E	135.0
10/16/02	1:00 AM	4	1E	135.3
10/16/02	9:00 AM	1	5E	135.8
10/16/02	5:00 PM	2	6E	134.9
10/17/02	1:00 AM	3	7E	134.9
10/17/02	9:00 AM	4	1E	136.5
10/17/02	5:00 PM	1	5E	136.7
10/18/02	1:00 AM	2	6E	135.7
10/18/02	9:00 AM	3	7E	134.9
10/18/02	5:00 PM	4	1E	135.0
10/19/02	1:00 AM	1	5E	134.7
10/19/02	9:00 AM	2	6E	134.2
10/19/02	5:00 PM	3	7E	134.3
10/20/02	1:00 AM	4	1E	135.2
10/20/02	9:00 AM	1	5E	135.8
10/20/02	5:00 PM	2	6E	134.9
10/21/02	1:00 AM	3	7E	135.2
10/21/02	9:00 AM	4	1E	136.0
10/21/02	5:00 PM	1	5E	136.4
10/22/02	1:00 AM	2	6E	135.8
10/22/02	9:00 AM	3	7E	135.1
10/22/02	5:00 PM	4	1E	135.8
10/23/02	1:00 AM	1	5E	136.4
10/23/02	9:00 AM	2	6E	135.6
10/23/02	5:00 PM	3	7E	135.2
10/24/02	1:00 AM	4	1E	135.7
10/24/02	9:00 AM	1	5E	136.1
10/24/02	5:00 PM	2	6E	135.0
10/25/02	1:00 AM	3	7E	134.5
10/25/02	9:00 AM	4	1E	135.4

Table 2. First Stage Digester Temperatures

Digester	7-Oct	8-Oct	9-Oct	10-Oct	11-Oct	15-Oct	16-Oct	17-Oct	18-Oct	21-Oct	22-Oct	23-Oct	24-Oct
1D1	135	134.4	133	135	135	135	136	136	133	135	134	134	133.8
2D1	135	134.2	134	134.8	137	136.4	136	136	134	135	134	135	135.5
3D1	138	140.6	139	136.4	136	135	137	135	133	135	134	135	135.8
4D1	135	136.4	135	136.4	137	135	135	135	134	134	136	134	134.9
5D1	134	134.2	133	133.4	135	135	136	135	134	134	134	134	132.5
6D1	135	135.6	135	135.5	137	134	133	133	133	135	134	134	133.5
1D2	138	138.4	138	134	136	133	136	138	135	134	134	136	136
2D2	140	139.5	138	137	136	137	139	136	133	136	136	137	137
3D2	139	139.3	137	135	136	136	137	137	135	136	137	136	135
4D2	138	137.3	135	134	136	134	135	135	135	137	138	138	136
5D2	138	137.5	136	134	136	137	138	137	134	133	133	136	137
6D2	133	131.7	132	134	136	135	137	135	132	136	136	133	132
2E	136	136.4	136	136	136	134	134	134	133	137	137	138	137
3E	138	137.8	136	135	137	133	135	137	134	135	136	136	135
4E	138	136.6	133	131	132	133	134	135	132	136	136	137	134
8E	134	135.9	137	137	138	137	137	137	138	136	137	138	137
Average	136.5	136.6	135.4	134.9	136	135	135.9	135.7	133.9	135.3	135.4	135.7	135.1
STD	2.1	2.3	2.1	1.5	1.3	1.4	1.6	1.3	1.5	1.1	1.5	1.6	1.6
Min	133	131.7	132	131	132	133	133	133	132	133	133	133	132
Max	140	140.6	139	137	138	137	139	138	138	137	138	138	137

Table 3. Sampling Protocol for Indicators and Pathogens

						Week1					Week2					Week3					Sample Containers
Sample Type	Sample	Analysis	Lab	Sampling Time	Sampling Party	10/7 Mon	10/8 Tue	10/9 Wed	10/10 Thu	10/11 Fri	*10/14 Mon	10/15 Tue	10/16 Wed	10/17 Thu	10/18 Fri	10/21 Mon	10/22 Tue	10/23 Wed	10/24 Thu	10/25 Fri	
Raw Sludge	Primary Sludge	Total solids	EMD	7:00 AM	HTP / Digester	S	S	S	S	S	NS	S	S	S	S	NS	NS	NS	NS	NS	One 500 ml plastic bottle
		Salmonella	EMD	7:00 AM		S	S	S	S	S	NS	S	S	S	S	NS	NS	NS	NS	NS	One 1 L plastic bottles
		Helminth Ova	BioVir	7:00 AM		S	S	S	S	S	NS	S	S	S	S	NS	NS	NS	NS	NS	One sterile 500 ml plastic bottle
		Enteric Virus	BioVir	7:00 AM		S	S	S	S	S	NS	S	S	S	S	NS	NS	NS	NS	NS	One sterile 500 ml plastic bottle
WET Cake	[1]Farm	**Silo** to load the designated truck for farm sample				NA	NA	NA	**1**	**2**	NA	**3**	**4**	**5**	**6**	**7**	**8**	**1**	**2**	NA	
		Fecal Coliform	EMD	7:00 AM	WESD / Applied Research HTP HRDD	NS	NS	NS	S	S	NS	S	S	S	S	S	S	S	S	NS	One sterile 18 oz. plastic bag
		Total solids	EMD	7:00 AM		NS	NS	NS	S	S	NS	S	S	S	S	S	S	S	S	NS	One 500 ml plastic bottle
		Salmonella	EMD	7:00 AM		NS	NS	NS	S	S	NS	S	S	S	S	S	S	S	S	NS	One 1 L plastic bottles
		Helminth Ova	BioVir	7:00 AM		NS	NS	NS	S	S	NS	S	S	S	S	S	S	S	S	NS	One sterile 500 ml plastic bottle
		Enteric Virus	BioVir	7:00 AM		NS	NS	NS	S	S	NS	S	S	S	S	S	S	S	S	NS	One sterile 500 ml plastic bottle

NA = Not Applicable; S = Sample to be collected; NS = No Sample to be collected

* 10/14 is Columbus Day (holiday).

[1] Farm samples will be collected from the designated truck.

Note: Temperature of sample will be measured and recorded for farm sample.

[ ] : These samples will be composited at BioVir Lab for the analysis.

Table 4. Analytical Procedures

Parameter	Method/reference
Fecal coliform	9221-B and 9221-E.1 (APHA, 1992)
Salmonella sp.	Kenner and Clark (1974)
Viable helminth ova	EPA (1987)
Enteric viruses	D 4994-89 (ASTM, 1992)
Total solids	2540-G (APHA, 1992)
QA/QC	9020 (APHA, 1992), EPA (1999)

Table 5. Indicator and Pathogen Counts and Temperatures

		Week 1					Week 2				Week 3			
Location	**Analysis**	**10/7 Mon**	**10/8 Tue**	**10/9 Wed**	**10/10 Thur**	**10/11 Fri**	**10/15 Tue**	**10/16 Wed**	**10/17 Thur**	**10/18 Fri**	**10/21 Mon**	**10/22 Tue**	**10/23 Wed**	**10/24 Thu**
PS	Salmonella	4.2	7.7	15	4.7	< 1.9	2.1	4.3	2.1	< 2.0				
	Helminth Ova	< 1					< 1							
	Enteric virus	39					43							
Farm	Ambient Temp				54	53	53	49	51.5	49	48	53	49.7	51
	Wetcake Temp (designated truck)				127.7	130.2	129.9	130	127.9	131.6	128.4	128.7	129.8	128.2
	Fecal coliform (designated truck)				< 6.4	< 6.4	< 6.6	< 6.5	< 6.6	< 6.8	< 6.9	< 6.8	< 6.5	< 6.6
	Wetcake Temp (non-designated Truck)										128.3	129.1	129.3	128.9
	Fecal coliform (non-designated Truck)										< 6.9	< 6.8	< 6.5	< 6.6
	Salmonella				< 1.4	< 1.4	< 1.4	< 1.3	< 1.4	< 1.5	< 1.5	< 1.5	< 1.4	< 1.4
	Helminth Ova				< 1						< 1			
	Enteric virus				< 1						< 1			