

Final Report
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Project Title: Manure and Nutrient Characterization for Flushed Manure for Use in Design Criteria for Innovative Treatment Technologies
NCPC Project #06M59MF1
Project Period: 07/01/2006 to 06/30/2007

Project Objectives:

The objective of this research was to measure and characterize the waste and nutrient production from a grow-finish swine facility. The term “waste” includes feces, urine and spilled water and feed. Characterization of “fresh manure” or “excreted” manure and the associated nutrients, solids, and chemical oxygen demand for designing waste treatment systems is typically based on either data that is often 20-30 years old or based on prediction equations (input minus retention equals excretion) developed mainly with equations derived from the 1998 NRC publication for swine nutrition requirements. There is a lack of modern data on measurement of waste as collected from actual swine production facilities. This information is needed for several purposes, with one need being as the waste characterization information for designing innovative manure treatment systems, and another need being to determine accurate inputs to the present anaerobic lagoon treatment system. In this project, manure collection was measured for a grow-finish swine facility that has a flush-tank system for flushing manure from the barn. The benefit of this research is to provide measured values of waste production for design of waste treatment and utilization systems.

Methods:

The project was conducted at a commercial farm owned by Murphy-Brown, Inc. The original proposal was to use a finishing barn at a research farm near Raleigh that has a 2,500 gal. collection tank that can collect the flushed waste and mix it well to get a representative sample. However, the review of the proposal expressed a concern that the research farm facility would not be representative of the all-in, all-out schedule used in the industry, and this might impact the nutrient content measurements and accuracy with which to describe modern production facilities and systems. Also, the research facility has smaller barns, and does not typically use the same phased diet representative of the industry. Thus, discussions with Dr. Prince Dugba of Smithfield Foods led to conducting the tests at a commercial farm owned by Murphy-Brown which already had some infrastructure that would be useful to the project. Murphy-Brown assisted in getting the site ready for tests including installing some valves and conducting additional maintenance at their expense.

The finishing barns were partial slat with one flush tank (750 gal.) per barn. The flush would alternate between the two alleys, thus requiring two tank-fulls to entirely flush the barn. Thus, a complete flush of the four barns required 6,000 gal. of flush liquid which was pumped from a lagoon-storage pond.

After a new group of pigs was put into the barns near the end of November 2006, the first tests were conducted in December 2006. Two 24-hr. collection periods were used for determining volume and for sampling for waste characterization. The tanks were manually flushed on the first day at a certain time so that the tanks could then be manually controlled to flush starting at the same time on days #2 and #3. The flow rates to the flush tanks were also measured with a bucket and timer, and valves were adjusted to obtain fairly equal flow rates for the tanks. Filling of a flush tank required about 1.5 hr., so the sampling per 24-hr period was limited to one total flush of barns (6,000 gal.). Volumes of flushed waste were collected in three different batches each of the two days. The three batch collections each day consisted of the “overnight base flow” (without flushing) from four barns, the flush of the first four tanks, and the flush of the second four tanks. Total volumes of flushed waste were 10,800 gal. the first day and 12,600 gal. the second day. Approximately 6,000 gal. each day was the lagoon liquid that was used to flush the barns.

The mixing of the waste in the collection tank was not adequate to prevent settling of solids to the bottom of the tank. Samples of collected waste were obtained with a 12-ft. pipe with valve at the bottom of the pipe to collect “cores” (three) while the tank contents were being mixed, and also taking samples every three minutes when the tank contents were discharged to the storage pond. These methods attempted to account for the problem of solids settling. However, without cleaning the tank after each collection, which was too labor intensive and time consuming to reasonably accomplish, there remained questions about whether the samples were representative. Also, it was discovered that the flush tanks did not alternate between the alleys sometimes because of unplugging the controller for flush control sometimes. Thus, the first 2 days of collection were not considered to be adequate data, and is not included in the results.

After the first collection period, it was decided that a better method to sample the flushed waste would be to install an electric valve on the discharge line at the Lift Station (6 ft. wide, 12 ft. long, 8 ft. deep) that pumps the flushed waste collected from the barn, and open this valve every minute or similar time unit to obtain samples frequently throughout the pumping period. The lift station has two pumps and one of the pumps has a “recirculation” pipe for mixing the contents in the Lift Station. Thus, the waste was considered to be well mixed as it was pumped from the lift station. The sampling valve was open about 2.7 sec. and closed for 60 sec. resulting in 0.6 to 0.7 gal./sample each time the valve opened. The lift station pumps typically operated for a total of 17 min. to pump the flush from four flush tanks, resulting in 11 to 12 gal. of total sample from each flush (of four flush tanks). Samples were collected in a barrel, mixed well and sub-sampled by taking “cores” with a pipe with a ball valve on the end of the pipe. The flow volumes were determined from timers on the pumps and flow rates measured periodically with a portable flow meter (Hydra SX 30 Portable Dual Frequency Doppler Ultrasonic Flowmeter, Polysonics, Inc., Houston, TX). Fresh water use was recorded from flow meters on the fresh water lines for February, March and May, but not for January.

Samples were taken for “overnight base flow”, each flush of four flush tanks (flushing one alley per barn), and also for a “washdown” of about 5 to 10 min. near mid-day

(except for the February sampling). The lines from the lagoon to the flush tanks were acid cleaned in January, so the fill time for the flush tanks were about 1 hour. Two flushes of each alley could be accomplished each day, resulting in 12,000 gal. of lagoon liquid used for flushing. Samples of the flush liquid from lagoon/storage pond were taken about mid-day at each flush tank, composited into one sample, and analyzed so that the mass of nutrients in the flush liquid could be subtracted from the total flushed waste.

Characterization of the wastes was determined for four finishing barns (capacity of 1220 pigs/barn) during December 12-14, 2006, January 23-25, 2007, February 20-23, 2007, and March 19-21, 2007. By the March sampling dates, 524 of the pigs had been removed (sold). As mentioned previously, the December 2006 data is not included in the results because of questionable quality of the data due to problems with solids settling in the large (8,000 gal.) collection tank and flush tank controller errors. After a new group of pigs were placed at the end of April, another sampling period was conducted May 15-17, 2007. The number of pigs and the estimated average pig weights for the January, February, March and May sampling periods were 4524 (130 lb.), 4189 (169 lb.), 3515 (202 lb.), and 4875 (75 lb.) Pig weights were estimated for the times of sampling of the first group of pigs by using the data from each barn for average weight at placement, the average daily gain from the farm report after the pigs were sold, and the number of days since placement. For the second group of pigs which were sampled in May, the average daily gain was assumed based on the average of the four barns from the first group, and the mortality was assumed equal per week for each barn.

Samples were put on ice and transported to the laboratory daily. Sample analyses were conducted by the Environmental Analysis Laboratory in the Biological and Agricultural Engineering Department at NC State University. Sample analyses included: total Kjeldahl nitrogen (TKN), total ammoniacal nitrogen (NH₃N), total phosphorus (TP), ortho-phosphate phosphorus (OPO₄P), chloride (Cl), chemical oxygen demand (COD), total solids (TS), volatile solids (VS), suspended solids (SS), sodium (Na), potassium (K), calcium (Ca), Magnesium (Mg), copper (Cu), zinc (Zn), pH and alkalinity (ALKAL).

Results:

A summary table of the volume of waste and mass of selected parameters is shown in Table 1. The volume of waste is shown per pig and per 1000 lb. live weight (LW). The total mass of solids and nutrients (average per day) and mass per 1000 lb LW per day are presented. For comparison, the manure production table values from the ASABE standard D384.2 (March 2005) and the Midwest Plan Service (MWPS) series 18 section 1 (2000) are also shown. In addition the values from the previous ASABE standard D384.1 (December 2003) are also shown for comparison. The ASABE and MWPS values are for manure production as excreted, except the MWPS table mentions possible inclusion of some wasted feed. Their values are also for an average size pig of about 150 lb. in the latest tables. The table values for volume of waste produced are about 8-10 gal./d/1000 lb LW, or about 1.2 to 1.4 gal./d/pig. The results from the four sampling periods for collected waste were in the range of 8.4 to 14.4 gal./d/1000 lb LW, and 1.1 to 2.1 gal./d/pig. Thus, values seem to compare reasonably well, especially after allowing for some wasted water and cleaning water added to the barn or flushed waste. The fresh

water use (not shown in Table 1) for February, March and May were 2.66, 2.58 and 0.95 gal./d/pig, respectively, or 15.78, 12.77 and 12.77 gal./d/1000 lb LW, respectively. For February and March, the waste collection was less than fresh water use, but slightly more than fresh water use for May.

One of the important nutrients to consider is nitrogen (N). The table values for N produced by an average size finishing pig vary from 0.52 to 0.56 lb/d/1000 lb LW. The collected N varied from 0.25 to 0.38 lb/d/1000 lb LW. This lower amount could reflect losses of nitrogen by ammonia losses in the barn and also some losses due to solids settling or accumulating on the barn surfaces, in the pit, or in the lift station. These sampled values are very similar to data reported by Vanotti (2004) of N collected in range of 0.18 to 0.42 with an average of 0.29 lb N/d/1000 lb LW for finishing barns with pit-recharge flush system.

Another important nutrient to consider is phosphorus (P). The table values for P produced by an average size finishing pig is 0.09 to 0.18 lb P/d/1000 kg LW. The collected P varied from 0.039 to 0.082 lb P/d/1000 kg LW. The P collected is less than the P produced according to the tables, and “storage” within the system could account for at least some of this difference.

The total solids (TS) produced by an average size finishing pig is 6.67 lb TS/d/1000 lb LW from the most recent tables. The collected TS from the sampling periods varied from 2.09 to 4.71 lb TS/d/1000 lb LW. For VS, the most recent values of production is 5.33 lb VS/d/1000 lb LW, while the sampling periods collected VS varied from 1.53 to 3.40 lb TS/d/1000 lb LW. Vanotti (2004) did not report TS or VS collection, but he reported total suspended solids (TSS) as ranging from 1.1 to 3.4 with an average of 1.93 lb TSS/d/1000 lb LW. These TSS values from Vanotti (2004) are very similar to the VS values from this study.

The potassium (K) and chloride (Cl) are soluble constituents and showed some variation between collection periods (0.15 to 0.25 lb K/d/1000 lb LW and 0.06 to 0.10 lb Cl/d/1000 lb LW). The recent table values for K are about 0.23 lb K/d/1000 lb LW which is at the upper range of our collected values. The K accumulation in the barn or flushing system would be expected to be low, but could possibly be in material accumulated on the barn surfaces.

Another parameter sometimes used for designing waste treatment is the Chemical Oxygen Demand (COD). The recent ASABE COD value for waste production from an average size finishing pig is 5.6 lb COD/d/1000 lb LW, while the collected COD varied from 2.7 to 7.7 lb COD/d/1000 lb LW.

Figure 1 shows for selected parameters the collection per 1000 lb LW per day for four different average pig weights (75, 130, 169 and 202 lb.). The ASABE D384.2 manure production standard has a model for excretion that predicts a decrease in N excretion per 1000 lb LW with increasing weight, and another study of collected manure from a pit-recharge system (M. Vanotti, unpublished data) indicated a similar decreasing trend for

collection of N per 1000 lb LW. The data in Fig. 1 would appear to follow that trend except the results for January 23-25, 2007 for 130 lb. average weight pigs is noticeably lower than the other values for N, P, TS, VS and COD. In January, the mid-day cleaning of the lift station reservoir with fresh-water hose was not done, but was done in February, March and May. This may have resulted in less solids and nutrients collected per unit LW in January. Also, the waste collection per 1000 lb LW was lower in January than the other months. The volume of waste would include wasted drinking water and cleaning water, and would likely vary with the time of year as well as the size of pig. In the lower right graph of Figure 1, it is seen that the volume of waste collected per pig was similar for the 75 and 130 lb pigs, and increased to a higher value for the 169 and 202 lb pigs.

Tables A-1 and A-2 show mean concentrations (total mass divided by total flow volume) and mass for each collection day for the total flushed waste, the flush liquid input, and the difference as calculating the manure input. The flush liquid input can vary greatly depending upon how many flushes are made and the quality of the flush liquid, and this must be considered in designing waste treatment and storage systems regarding flow rates, flow volumes and loading rates of nutrients and oxygen demand.

References:

ASABE D384.2 MAR2005. 2005. Manure production and characteristics. ASABE, St. Joseph, MI.

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MWPS-18. 2000. Manure characteristics. Manure Management Systems Series, MWPS-18 Section 1. Midwest Plan Service, Ames, IA.

Vanotti, M. B. 2001. Evaluation of environmentally superior technology: Final report for technology determination per Agreements between the Attorney General of North Carolina and Smithfield Foods, Premium Standard Farms, and Frontline Farmers. North Carolina State University, Animal and Poultry Waste Management Center. Available at: www.cals.ncsu.edu/waste_mgt/smithfield_projects/phase1report04/A.9Super%20Soil%20final.pdf

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Summary (lay interpretation):

The objective of this research was to measure and characterize the waste and nutrient production from a grow-finish swine facility. The term “waste” includes feces, urine and spilled water and feed. Characterization of “fresh manure” or “excreted” manure and the

associated nutrients, solids, and chemical oxygen demand for designing waste treatment systems is typically based on either data that is often 20-30 years old or based on prediction equations (input minus retention equals excretion) developed mainly with equations derived from the 1998 NRC publication for swine nutrition requirements. There is a lack of modern data on measurement of waste as collected from actual swine production facilities. This information is needed for several purposes, with one need being as the waste characterization information for designing innovative manure treatment systems, and another need being to determine accurate inputs to the present anaerobic lagoon treatment system or covered digesters for methane production. In this project, manure collection was measured for a grow-finish swine facility that has a flush-tank system for flushing manure from the barn. The benefit of this research is to provide measured values of waste production for design of waste treatment and utilization systems.

Measurement of manure collection is difficult because of difficulty in measuring flow rates and/or total flow, and being able to collect representative samples of the entire flow. In this project, the flow was calculated by using the time of pumping from a lift station which received the waste flushed from the finishing barns, and the flow rate in the pipe to the lagoon was periodically measured with a portable Doppler ultrasonic flow meter. The waste samples were collected by opening and closing a portable valve periodically to divert a sample taken after every minute from the discharge pipe into a collection barrel and then sub sampling the total collection from four barns for each flush, and for overnight base flow when flushing was not occurring. Thus, many samples were taken to attempt to capture any variability in the flushed waste. Sampling was performed for two 24-day collection periods at four different average pig sizes (75, 130, 169 and 202 lb.). The 130, 169 and 202 lb pig sampling periods were during January, February, and March 2007 and the 75 lb. pig sampling period was in May 2007.

Results from the four sampling periods indicated that the solids and nutrients collected varied with size of pig when expressed per unit of live weight (LW). The contribution of the lagoon liquid used for flushing was subtracted out in order to calculate the manure contribution. There appeared to be a decreasing trend per unit LW as the weight of pigs increased. However, the 130 lb. pig values (January) per unit LW were lower than for the larger pigs, and the reason for this may have been that the lift station reservoir was not cleaned with water hose at mid-day in the January sampling period. The ASABE standard for manure production of nitrogen, phosphorus and dry matter predicts less excretion per unit LW as the pig weight increases. Also, another study (M. Vanotti, personal communication) has found decreased collection per unit LW for nitrogen and solids as pig size increased. The range of values reported by Vanotti in a report was 0.18 to 0.42 with an average of 0.29 lb N/d/1000 lb LW for finishing barns with pit-recharge flush system. The collected N in our study varied from 0.25 to 0.38 lb/d/1000 lb LW, which is very similar to Vanotti's data. The excretion of N by an average finishing pig is predicted by ASABE and Midwest Plan Service tables and models to be slightly over 0.5 lb/d/1000 lb LW. Thus, the range of amount of N collected from flush systems in this sampling study was on the order of 50 % to 75 % of the predicted N excretion. Similarly, the range of amounts of phosphorus and volatile solids collected compared to ASABE

predicted excretion for an average size finishing pig was on the order of 50 to 90 % for phosphorus and 30 to 60 % for volatile solids. More detailed comparisons based on size of pig would be possible if the ASABE prediction equations were used for a particular size pig. The volume of waste collected ranged from 8 to 15 gal./d/1000 lb. LW.

Overall, measurement of characteristics of flushed pig manure indicates variability in volume and characteristics of waste that should be considered when designing treatment and storage components. It is difficult to representatively measure the waste stream, but data from this study and from a study by Vanotti are similar in many respects and present ranges of values that should be more useful for waste treatment system design than using the references for predicted manure excretion.

Table 1. Average mass collected per day (total and per 1000 lb LW), and manure production tables from ASABE and MWPS. Mass collection values are average of two 24-hr sampling periods for four finishing barns, and has subtracted out the contribution of the liquid used for flushing. There are three samplings from the first group of pigs and one sampling from the second group of pigs.

Parameter	Mass collected after subtracting contribution of liquid used for flushing								Manure Production Tables		
	1/25/2007		2/22/2007		3/21/2007		5/17/2007		ASABE D384.2 "MAR05	MWPS- 18 Sect. 1 2000	ASABE D384.1 "DEC01
	lb/d	lb/d/ 1000 lbLW	lb/d	lb/d/ 1000 lb LW	lb/d	lb/d/ 1000 lb LW	lb/d	lb/d/ 1000 lb LW	lb/d/ 1000 lb LW	lb/d/ 1000 lb LW	lb/d/ 1000 lb LW
TKN	149	0.25	232	0.33	229	0.32	137	0.38	0.56	0.53	0.52
TP	23	0.039	51	0.072	43	0.061	30	0.082	0.0905	0.14	0.18
K	91	0.15	119	0.17	101	0.14	90	0.25	0.23	0.22	0.29
Cl	38	0.07	55	0.08	45	0.06	38	0.10	NA	NA	0.26
TS	1226	2.09	2703	3.83	2187	3.08	1715	4.71	6.67	6.67	11
VS	897	1.53	2097	2.97	1706	2.41	1239	3.40	5.33	5.33	8.5
COD	1592	2.71	4716	7	3047	4.30	2817	7.73	5.6	NA	8.4
Volume of waste	gal.	gal./d/ 1000 lb LW	gal.	gal./d/ 1000 lb LW	gal.	gal./d/ 1000 lb LW	gal.	gal./d/ 1000 lb LW	gal./d/ 1000 lb LW	gal./d/ 1000 lb LW	gal./d/ 1000 lb LW
Volume of waste	4933	8.41	8867	12.55	7565	10.67	5268	14.45	7.9	8.0	10.2
Volume of waste	4933	gal./d/pig 1.09	gal./d/pig 2.12	gal./d/pig 2.15	gal./d/pig 1.08	gal./d/pig 1.22	gal./d/pig 1.20	gal./d/pig 1.37	gal./d/pig 1.22	gal./d/pig 1.20	gal./d/pig 1.37
Avg. pig wt. (lb)	130		169		202		75		154	150	135
No. of pigs	4524		4189		3515		4875				
Total LW (lb)	586550		706309		709147		364446				

* Waste volume includes wasted water and wasted feed, and is calculated by taking total volume and subtracting volume of liquid used for flushing.

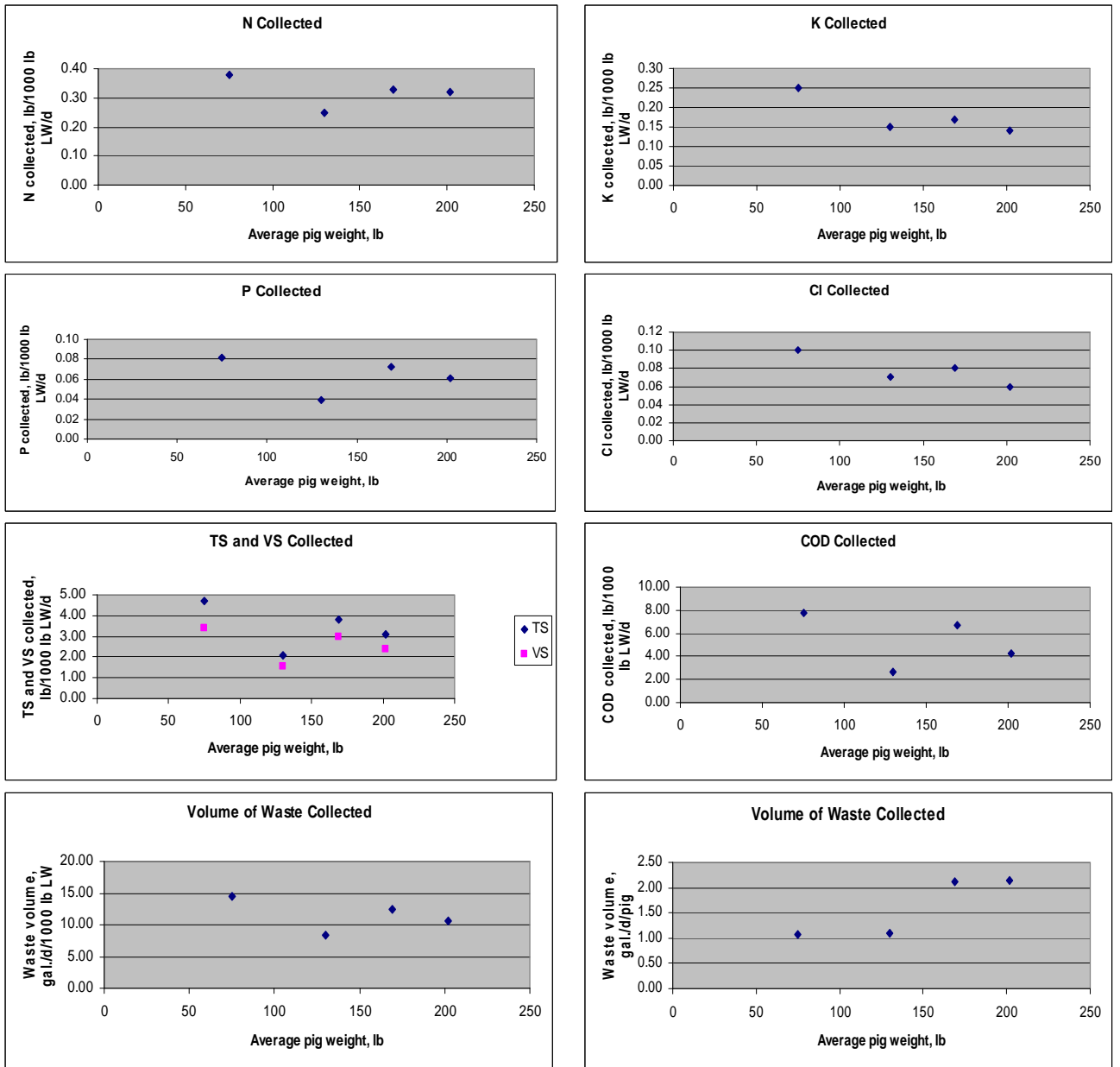


Figure 1. Collection of selected parameters per day per 1000 lb. LW for four different sizes of pigs. Volume collected is also expressed per pig per day. The liquid used for flushing has been subtracted out.

Table A1. Concentrations: (1) in the flushed manure (volume weighted for four flushes plus overnight base flow plus any wash-down), (2) in the liquid used for flushing, and (3) calculated for just the manure (plus any wasted water and wasted feed).

Units of concentration are mg/L, except % for solids, pH units for pH, and mg/L calcium carbonate equivalent for alkalinity.

TYPE	DATE	TKN (mg/L)	NH3N (mg/L)	TP (mg/L)	OPO4P (mg/L)	CL (mg/L)	COD (mg/L)	TS %	VS %	SS %	NA (mg/L)	K (mg/L)	CA (mg/L)	MG (mg/L)	CU (mg/L)	ZN (mg/L)	pH	ALKAL
Total	1/24/2007	1335	1030	184	138	528	11150	0.98	0.63	0.66	208	1154	139	88	0.73	6.17	8.37	4840
Flush Liq.	1/24/2007	398	370	48	33	338	1104	0.27	0.10	0.07	150	665	37	16	0.00	0.56	8.06	2000
Manure	1/24/2007	3930	2858	561	431	1055	38971	2.94	2.12	2.27	367	2510	423	286	2.74	21.69		
Total	1/25/2007	1343	1057	215	120	478	12919	1.14	0.78	0.98	234	1038	140	103	0.47	8.14	8.40	4700
Flush Liq.	1/25/2007	394	365	59	29	311	1134	0.28	0.11	0.08	155	607	34	17	0.00	0.76	7.93	2000
Manure	1/25/2007	3400	2559	553	317	840	38483	3.01	2.23	2.93	405	1974	369	289	1.49	24.14		
Total	2/21/2006	1716	1137	310	189	530	29297	1.76	1.31	1.50	240	1047	271	156	2.19	13.35	7.89	5500
Flush Liq.	2/21/2006	548	408	39	35	338	1464	0.30	0.11	0.07	147	649	54	16	0.20	0.90	7.95	2300
Manure	2/21/2006	3346	2154	687	403	798	68116	3.80	2.99	3.49	370	1603	573	352	4.96	30.72		
Total	2/22/2007	1550	1126	336	183	488	26623	1.68	1.23	1.45	228	1043	257	156	1.97	11.90	7.99	5400
Flush Liq.	2/22/2007	496	430	69	34	328	1514	0.28	0.11	0.07	140	600	36	14	0.08	0.56	7.97	2300
Manure	2/22/2007	2936	2042	687	380	699	59628	3.52	2.69	3.26	344	1626	547	342	4.45	26.80		
Total	3/20/2007	1694	1186	240	179	483	15411	1.16	0.79	0.92	241	1051	194	108	1.04	9.10	8.37	5167
Flush Liq.	3/20/2007	641	458	69	49	319	1878	0.32	0.12	0.08	170	744	57	21	0.18	1.90	8.02	2500
Manure	3/20/2007	3663	2548	559	423	789	40719	2.72	2.04	2.50	375	1626	450	270	2.64	22.55		
Total	3/21/2007	1959	1054	376	204	456	23720	1.88	1.42	1.61	239	1065	289	157	1.48	15.08	8.09	5250
Flush Liq.	3/21/2007	767	459	87	41	308	1876	0.33	0.13	0.09	166	689	59	22	0.21	2.30	8.05	2500
Manure	3/21/2007	3602	1873	775	428	659	53809	4.01	3.19	3.72	339	1582	605	344	3.22	32.68		
Total	5/16/2007	1294	800	241	171	501	19690	1.36	0.88	1.18	241	1068	198	114	1.43	12.23	7.63	4333
Flush Liq.	5/16/2007	450	416	47	34	339	1294	0.31	0.12	0.07	158	676	65	24	1.30	1.80	7.87	2500
Manure	5/16/2007	3172	1656	674	474	863	60625	3.68	2.57	3.63	424	1941	495	313	1.71	35.45		
Total	5/17/2007	1237	818	242	195	494	21247	1.44	1.01	1.22	243	1111	189	124	2.12	12.69	7.79	4433
Flush Liq.	5/17/2007	451	391	49	36	342	1308	0.29	0.12	0.07	153	663	44	22	0.18	1.30	7.89	2400
Manure	5/17/2007	3070	1813	692	566	850	67779	4.14	3.08	3.89	452	2155	526	361	6.65	39.27		

Table A2. Daily volumes and mass of parameters: (1) in the total flushed manure (including four flushes, overnight base flow and any wash-down), (2) in the liquid used for flushing, and (3) calculated for the manure (plus any wasted water and wasted feed).

TYPE	DATE	Volumes		Mass (kg)														
		Vol. (gal.)	Vol. (L)	TKN	NH3N	TP	OPO4P	CL	COD	TS	VS	FSS	NA	K	CA	MG	CU	ZN
Total	1/24/2007	16333	61820	83	64	11.4	8.6	33	689	604	392	406	12.83	71.37	8.62	5.43	0.04	0.38
Flush Liq.	1/24/2007	12000	45420	18	17	2.2	1.5	15	50	123	45	33	6.81	30.20	1.67	0.74	0.00	0.03
Manure	1/24/2007	4333	16400	64	47	9.2	7.1	17	639	482	348	373	6.02	41.17	6.94	4.68	0.04	0.36
Total	1/25/2007	17532	66359	89	70	14.3	8.0	32	857	758	518	648	15.51	68.89	9.28	6.82	0.03	0.54
Flush Liq.	1/25/2007	12000	45420	18	17	2.7	1.3	14	52	127	51	35	7.04	27.57	1.56	0.76	0.00	0.03
Manure	1/25/2007	5532	20939	71	54	11.6	6.6	18	806	631	467	613	8.47	41.32	7.72	6.06	0.03	0.51
Total	2/21/2006	20604	77986	134	89	24.1	14.7	41	2285	1374	1022	1167	18.74	81.67	21.12	12.20	0.17	1.04
Flush Liq.	2/21/2006	12000	45420	25	19	1.8	1.6	15	66	136	50	30	6.68	29.48	2.45	0.73	0.01	0.04
Manure	2/21/2006	8604	32566	109	70	22.4	13.1	26	2218	1238	972	1137	12.06	52.19	18.67	11.48	0.16	1.00
Total	2/22/2007	21129	79973	124	90	26.9	14.7	39	2129	1342	981	1159	18.25	83.43	20.54	12.47	0.16	0.95
Flush Liq.	2/22/2007	12000	45420	23	20	3.2	1.5	15	69	127	50	33	6.36	27.25	1.64	0.65	0.00	0.03
Manure	2/22/2007	9129	34553	101	71	23.7	13.1	24	2060	1215	931	1126	11.89	56.17	18.91	11.81	0.15	0.93
Total	3/20/2007	18417	69708	118	83	16.7	12.5	34	1074	807	550	642	16.83	73.29	13.51	7.51	0.072	0.63
Flush Liq.	3/20/2007	12000	45420	29	21	3.1	2.2	14	85	145	56	35	7.72	33.79	2.59	0.95	0.008	0.09
Manure	3/20/2007	6417	24288	89	62	13.6	10.3	19	989	662	494	607	9.11	39.50	10.93	6.56	0.064	0.55
Total	3/21/2007	20712	78395	154	83	29.5	16.0	36	1860	1472	1113	1265	18.70	83.47	22.64	12.34	0.116	1.18
Flush Liq.	3/21/2007	12000	45420	35	21	4.0	1.9	14	85	150	60	39	7.54	31.29	2.68	1.00	0.010	0.10
Manure	3/21/2007	8712	32975	119	62	25.5	14.1	22	1774	1322	1053	1226	11.16	52.17	19.96	11.34	0.106	1.08
Total	5/16/2007	17393	65833	85	53	15.9	11.2	33	1296	892	578	774	15.84	70.32	13.06	7.47	0.094	0.81
Flush Liq.	5/16/2007	12000	45420	20	19	2.1	1.6	15	59	141	55	34	7.18	30.70	2.95	1.09	0.059	0.08
Manure	5/16/2007	5393	20413	65	34	13.8	9.7	18	1238	751	524	740	8.66	39.62	10.11	6.38	0.035	0.72
Total	5/17/2007	17142	64882	80	53	15.7	12.6	32	1379	937	655	791	15.74	72.06	12.24	8.02	0.138	0.82
Flush Liq.	5/17/2007	12000	45420	20	18	2.2	1.6	16	59	132	55	33	6.95	30.11	2.00	1.00	0.008	0.06
Manure	5/17/2007	5142	19462	60	35	13.5	11.0	17	1319	806	600	758	8.79	41.95	10.24	7.03	0.129	0.76

