Appendix A

Sector Production Rates fo KeyCounties in Representative States

Table A1. Top 3 Broiler and other Meat-type Chicken Production Counties in the Top 10 States

State	County	1997 Broilers, inventory (number)	County Rank in State
AL	Cullman	20,029,478	1
AL	DeKalb	12,953,525	2
AL	Blount	10,220,614	3
AR	Benton	18,348,364	1
AR	Washington	15,845,360	2
AR	Hempstead	9,162,825	3
CA	Fresno	9,818,303	1
CA	Sonoma	2,008,375	2
CA	Kings	1,469,027	3
GA	Franklin	8,450,377	1
GA	Habersham	7,338,725	2
GA	Hall	7,108,000	3
MD	Wicomico	12,675,801	1
MD	Worcester	10,021,828	2
MD	Somerset	6,989,402	3
MO	Barry	8,299,329	1
MO	Mcdonald	7,735,354	2
MO	Newton	4,333,686	3
MS	Scott	13,711,227	1
MS	Smith	11,244,047	2
MS	Simpson	7,542,642	3
NC	Wilkes	14,514,374	1
NC	Union	11,388,600	2
NC	Randolph	8,710,717	3
TX	Shelby	12,769,137	1
TX	Nacogdoches	11,456,185	2
TX	Gonzales	9,267,047	3
VA	Rockingham	17,491,765	1
VA	Page	7,209,771	2
VA	Accomack	4,238,230	3

Table A2. Top 3 Layer and Pullet Production Counties in the Top 10 States

State	County	1997 Layers and pullets inventory (number)	County Rank in State
AL	Cullman	2,939,027	1
AL	Marshall	1,743,461	2
AL	DeKalb	1,625,201	3
AR	Washington	3,691,259	1
AR	Benton	1,708,686	2
AR	Hempstead	1,438,997	3
CA	Riverside	9,897,627	1
CA	SanJoaquin	4,434,966	2
CA	Stanislaus	4,395,043	3
GA	Jackson	1,757,097	1
GA	Franklin	1,548,670	2
GA	Banks	1,429,562	3
IA	Clay	550,824	1
IA	BuenaVista	440,449	2
IA	O'brien	304,930	3
IN	Lagrange	418,681	1
IN	Washington	69,522	2
IN	Allen	19,841	3
NC	Nash	1,973,442	1
NC	Iredell	1,644,541	2
NC	Union	1,276,429	3
OH	Mercer	7,771,948	1
OH	Darke	6,635,500	2
OH	Auglaize	872,218	3
PA	Lancaster	11,502,343	1
PA	Lebanon	2,311,505	2
PA	Berks	2,072,684	3
TX	Gonzales	4,318,566	1
TX	Fayette	2,039,865	2
TX	Shelby	2,030,083	3

Table A3. Top 3 Beef Production Counties in the Top 10 States

State	County	1997 Cattle fattened on grain and concentrates sold (number)	County Rank in State
AR	Marion	2,148	1
AR	Carroll	1,651	2
AR	Benton	1,476	3
CA	Imperial	300,032	1
CA	Tulare	19,926	2
CA	Stanislaus	6,138	3
CO	Weld	837,839	1
CO	Yuma	360,338	2
CO	Morgan	353,768	3
FL*	Marion	877	1
FL*	Hillsborough	453	2
FL*	Okeechobee**	30	3
IA	Sioux	183,404	1
IA	Carroll	80,057	2
IA	Pottawattami	51,266	3
ID	Cassia	160,522	1
ID	Canyon	103,325	2
ID	Ada	24,313	3
KS	Scott	524,645	1
KS	Finney	471,413	2
KS	Haskell	457,229	3
NE	Cuming	447,343	1
NE	Dawson	334,105	2
NE	Phelps	293,702	3
OK	Texas	455,691	1
OK	Canadian	8,074	2
OK	Garfield	7,067	3
PA	Lancaster	58,100	1
PA	Berks	9,941	2
PA	York	9,378	3
TX	DeafSmith	789,240	1
TX	Castro	741,180	2
TX	Parmer	572,947	3

* Florida is not the top state in the South region, but is included

** Okeechobee County is not one of the top three counties in Florida, but it is included because it will be used in the model beef farm study.

Table A4. Top 3 Hog and Pig Production Counties in the Top 10 States

State	County	1997 Hogs and pigs (number)	County Rank in State
AR	Sevier	96,727	1
AR	Washington	80,787	2
AR	Howard	78,348	3
CA	Tulare	116,390	1
CA	Stanislaus	22,275	2
CA	SanBernardino	14,296	3
IA	Sioux	762,294	1
IA	Plymouth	460,965	2
IA	Hamilton	448,312	3
IL	Henry	224,082	1
IL	DeKalb	154,403	2
IL	Greene	153,927	3
IN	Carroll	255,176	1
IN	Clinton	181,579	2
IN	Daviess	154,715	3
MN	Martin	489,024	1
MN	BlueEarth	325,829	2
MN	Renville	258,970	3
MO	Vernon	145,219	1
MO	Gentry	139,106	2
MO	Miller	106,410	3
NC	Duplin	2,034,349	1
NC	Sampson	1,775,702	2
NC	Bladen	758,701	3
NE	Cuming	210,346	1
NE	Holt	199,974	2
NE	Platte	182,148	3
OK	Texas	907,046	1
OK	Hughes	125,474	2
OK	Mccurtain	39,326	3

Table A5. Top 3 Dairy Production Counties in the Top 10 States

State	County	1997 Milk cows (number)	County Rank in State
CA	Tulare	277,922	1
CA	Merced	187,717	2
CA	SanBernardino	185,249	3
FL	Okeechobee	35707	1
FL	Gilchrist	13960	2
FL	Lafayette	12985	3
ID	Gooding	63,415	1
ID	Jerome	59,107	2
ID	TwinFalls	30,730	3
MI	Sanilac	22,294	1
MI	Clinton	16,151	2
MI	Allegan	15,816	3
MN	Stearns	62,793	1
MN	OtterTail	30,344	2
MN	Winona	28,559	3
NY	Wyoming	45,281	1
NY	StLawrence	40,567	2
NY	Jefferson	30,047	3
OH	Wayne	30,349	1
OH	Holmes	16,428	2
OH	Mercer	16,154	3
PA	Lancaster	98,875	1
PA	Franklin	44,201	2
PA	Bradford	31,089	3
TX	Erath	81,413	1
TX	Hopkins	49,280	2
TX	Comanche	19,368	3
WI	Marathon	62,799	1
WI	Clark	59,735	2
WI	Grant	52,702	3

Table A6. Top 3 Turkey Production Counties in the Top 10 States

State	County	1997 Turkeys, inventory (number)	County Rank in State
AR	Franklin	2,171,146	1
AR	Benton	1,563,405	2
AR	Washington	1,360,555	3
CA	Fresno	1,880,583	1
CA	Merced	1,532,570	2
CA	Stanislaus	1,440,413	3
IN	Dubois	1,687,356	1
IN	Daviess	941,225	2
IN	Greene	457,100	3
MN	Kandiyohi	2,769,678	1
MN	Meeker	1,902,400	2
MN	Stearns	1,503,816	3
MO	Morgan	1,096,263	1
MO	Miller	1,070,879	2
MO	Newton	763,704	3
NC	Duplin	3,476,770	1
NC	Sampson	3,233,308	2
NC	Wayne	1,932,934	3
PA	Adams	809,290	1
PA	Franklin	473,741	2
PA	York	315,213	3
SC	Kershaw	894,038	1
SC	Lancaster	873,104	2
SC	Chesterfield	679,800	3
TX	Gonzales	983,575	1
TX	Milam	317,647	2
TX	Caldwell	239,457	3
VA	Rockingham	3,870,344	1
VA	Augusta	2,206,387	2
VA	Shenandoah	942,005	3

Appendix B.

Estimating Potential Overflows and Resultant Pollutant Loads from the Production Area of Beef Feedlots, Heifer Operations, and Dairies

ERG

MEMORANDUM

TO: CAFO Record

FROM: Kristy Fruit, ERG

DATE: November 26, 2002

SUBJECT: Estimating Potential Overflows and Resultant Pollutant Loads from the Production Area of Beef Feedlots, Heifer Operations, and Dairies

This memorandum describes the methodology developed by EPA to estimate the potential overflows and corresponding pollutant loads from liquid containment structures that occur over a 25-year period. EPA used this methodology to estimate overflows occurring at the production area of beef feedlots, heifer operations, and dairies due to the daily inputs to the storage system, including process wastes, direct precipitation, and runoff. EPA also evaluated the daily outputs from these storage systems, including losses due to evaporation, sludge removal, and the removal of wastewater for use on cropland on or off site. For purposes of this analysis, EPA defined the annual overflow as the median annual overflow over the 25 years evaluated. EPA coupled animal-specific pollutant characterization data with the overflow volume output from the model to predict the mass pollutant discharge for each facility. Finally, EPA used weighted facility counts to estimate the total industry pollutant loadings for beef feedlots, heifer operations, and dairies for both baseline systems and BAT systems.

This memorandum presents the following sections of the methodology:

- Section I describes the design basis for liquid storage systems at baseline and under BAT;
- Section II describes the estimation of the volume of overflow from a liquid storage system;
- Section III describes the estimation of the volume of overflow when there is no storage system in place;
- Section IV describes the use of waste characterization data to estimate the pollutant loads in the overflow from each system and the development of the mass pollutant discharge associated with each system.
- Section V describes the use of facility count data to estimate the industry-level pollutant loads for each animal type at Baseline and under BAT.

Examples for estimating the overflow from a Large beef feedlot and a Medium dairy are presented in Attachments A and B. The model farm overflow and pollutant loads results are presented in Attachment C. The facility counts used in the industry-level analysis are presented in Attachment D. The industry-level overflow and pollutant loads results are presented in Attachment E.

I Design of Liquid Storage Systems

BAT Systems

For purposes of this analysis, EPA assumes BAT liquid waste storage facilities (ponds and lagoons) are designed in accordance with the following resources:

- Natural Resources Conservation Service (NRCS) Code 313 Waste Storage Facility; and
- NRCS Code 359 Waste Treatment Lagoon.

NRCS Code 313. EPA used Code 313 in this analysis as the basis to size beef feedlot and heifer operation runoff ponds. The code requires ponds to be sized to contain manure, wastewater, and other wastes accumulated during the storage period; normal precipitation less evaporation on the surface area of the facility during the storage period; normal runoff from the facility's drainage area during the storage period; 25-year, 24-hour precipitation on the surface of the storage facility; 25-year, 24-hour runoff from the facility's drainage area; and residual solids after liquids have been removed. Additionally, the code stipulates that the facility be sized to contain any additional storage as required by regulatory or management requirements. NCRS requires the embankment surrounding the pond to be 1 foot above the required volume.

The NRCS code calls for the storage period to be based on the maximum amount of time between waste utilization. The code expects that waste (liquid and sludge) is utilized in an environmentally safe manner, accounting for site-specific conditions and local, state, and federal regulations.

NCRS Code 359. EPA used Code 359 in this analysis as the basis to design dairy waste treatment lagoons. According to the code, farmers must size waste treatment lagoons to hold all the materials included in the waste storage facility requirements (Code 313) and, additionally, size waste treatment lagoons to accommodate a minimum treatment volume.

Baseline Systems

Using site visit information and state and federal regulations, EPA assumes that all Large beef feedlots, Large heifer operations, and Large dairies have adequate storage for process wastewater consistent with NRCS Codes 313 and 359. Therefore, these Large facilities are expected to have the same liquid containment structures at Baseline and under BAT[1].

EPA developed frequency factors for Medium beef feedlots with naturally-lined ponds using site visit information and best professional judgment. Based on discussions with the Professional Dairy Heifer Growers Association, heifer operations were assumed to operate like beef feedlots, therefore, the same frequency factors for naturally-lined ponds were used. Frequency factors for Medium dairies with naturally-lined ponds are based on site visit information, NAHMS data, and current state and federal regulations.

Table 1 presents the percentage of beef feedlots, heifer operations, and dairies that do not have a naturally-lined pond or lagoon at baseline.

Table 1

[1]EPA. 2002. *Cost Methodology Report for Animal Feeding Operations.*

Percentage of Beef Feedlots, Heifer Operations, Dairies without a Naturally-Lined Pond or Lagoon at Baseline

Animal Type	Size Class	Percent of Facilities
Beef and Heifers	Medium 1	50%
	Medium 2	50%
	Medium 3	50%
	Large 1	0%
	Large 2[a]	0%
Dairy	Medium 1	10%
	Medium 2	10%
	Medium 3	10%
	Large 1	0%

[a] Large 2 size class only represents beef feedlots.

Table 2 presents the estimated days of existing storage capacity for both Large and Medium operations.

Table 2
Estimated Existing Storage Capacity (days)

Region	Beef Feedlot and Heifer Operations	Dairies
Central	50	60
Mid-Atlantic	80	30
Midwest	190	90
Pacific	30	30
South	45	30

II Estimating Overflow from a Liquid Storage System

This step describes EPA's method to determine the number and volume of overflows that would occur from a liquid storage system over a 25-year period. EPA used the design volume described previously to calculate the maximum existing pond or lagoon capacity, presented in Table 3.
Table 4 presents the calculated maximum pond or lagoon capacity for Medium operations that do not have storage at baseline and are costed by EPA to design a pond or lagoon with 180-days of storage under BAT[2].

[2]EPA. 2002. *Cost Methodology Report for Animal Feeding Operations.*

Table 3
Maximum Existing Storage Capacity (cf)

Animal	Type	Size	Region	Storage Volume (cf)
Beef	Beef	Large1	Central	56,668
Beef	Beef	Large1	MidAtlantic	337,484
Beef	Beef	Large1	MidWest	390,953
Beef	Beef	Large1	Pacific	143,346
Beef	Beef	Large1	South	226,890
Beef	Beef	Large2	Central	792,862
Beef	Beef	Large2	MidAtlantic	4,753,968
Beef	Beef	Large2	MidWest	5,472,785
Beef	Beef	Large2	Pacific	2,016,083
Beef	Beef	Large2	South	3,194,136
Beef	Beef	Medium1	Central	11,688
Beef	Beef	Medium1	MidAtlantic	68,936
Beef	Beef	Medium1	MidWest	78,194
Beef	Beef	Medium1	Pacific	28,874
Beef	Beef	Medium1	South	45,630
Beef	Beef	Medium2	Central	17,139
Beef	Beef	Medium2	MidAtlantic	102,508
Beef	Beef	Medium2	MidWest	117,579
Beef	Beef	Medium2	Pacific	43,784
Beef	Beef	Medium2	South	69,067
Beef	Beef	Medium3	Central	23,468
Beef	Beef	Medium3	MidAtlantic	141,752
Beef	Beef	Medium3	MidWest	162,162
Beef	Beef	Medium3	Pacific	60,278
Beef	Beef	Medium3	South	95,343
Dairy	Flush	Large1	Central	2,837,332
Dairy	Flush	Large1	MidAtlantic	3,017,618
Dairy	Flush	Large1	MidWest	4,040,766
Dairy	Flush	Large1	Pacific	2,840,664
Dairy	Flush	Large1	South	2,342,473
Dairy	Flush	Medium1	Central	613,587
Dairy	Flush	Medium1	MidAtlantic	629,343
Dairy	Flush	Medium1	MidWest	884,644
Dairy	Flush	Medium1	Pacific	614,706
Dairy	Flush	Medium1	South	530,464
Dairy	Flush	Medium2	Central	966,056
Dairy	Flush	Medium2	MidAtlantic	1,001,615
Dairy	Flush	Medium2	MidWest	1,390,148

Animal	Type	Size	Region	Storage Volume (cf)
Dairy	Flush	Medium2	Pacific	966,774
Dairy	Flush	Medium2	South	819,620
Dairy	Flush	Medium3	Central	1,320,392
Dairy	Flush	Medium3	MidAtlantic	1,367,759
Dairy	Flush	Medium3	MidWest	1,895,358
Dairy	Flush	Medium3	Pacific	1,313,423
Dairy	Flush	Medium3	South	1,099,007
Dairy	Hose	Large1	Central	1,923,342
Dairy	Hose	Large1	MidAtlantic	2,507,151
Dairy	Hose	Large1	MidWest	2,673,229
Dairy	Hose	Large1	Pacific	2,308,799
Dairy	Hose	Large1	South	1,816,448
Dairy	Hose	Medium1	Central	355,877
Dairy	Hose	Medium1	MidAtlantic	482,183
Dairy	Hose	Medium1	MidWest	515,386
Dairy	Hose	Medium1	Pacific	454,177
Dairy	Hose	Medium1	South	361,735
Dairy	Hose	Medium2	Central	589,240
Dairy	Hose	Medium2	MidAtlantic	786,454
Dairy	Hose	Medium2	MidWest	836,553
Dairy	Hose	Medium2	Pacific	733,732
Dairy	Hose	Medium2	South	583,922
Dairy	Hose	Medium3	Central	826,160
Dairy	Hose	Medium3	MidAtlantic	1,093,214
Dairy	Hose	Medium3	MidWest	1,155,247
Dairy	Hose	Medium3	Pacific	1,004,803
Dairy	Hose	Medium3	South	798,449

Table 4

Maximum 180-days Storage Capacity (cf)

Animal	Type	Size	Region	Storage Volume (cf)
Beef	Beef	Medium1	Central	59,650
Beef	Beef	Medium1	MidAtlantic	121,319
Beef	Beef	Medium1	MidWest	127,878
Beef	Beef	Medium1	Pacific	155,737
Beef	Beef	Medium1	South	141,037
Beef	Beef	Medium2	Central	88,991
Beef	Beef	Medium2	MidAtlantic	180,995
Beef	Beef	Medium2	MidWest	190,780
Beef	Beef	Medium2	Pacific	232,342
Beef	Beef	Medium2	South	210,412
Beef	Beef	Medium3	Central	123,492
Beef	Beef	Medium3	MidAtlantic	251,163
Beef	Beef	Medium3	MidWest	264,742
Beef	Beef	Medium3	Pacific	322,417
Beef	Beef	Medium3	South	291,984
Dairy	Flush	Medium1	Central	1,112,529
Dairy	Flush	Medium1	MidAtlantic	1,384,605
Dairy	Flush	Medium1	MidWest	1,292,325
Dairy	Flush	Medium1	Pacific	1,455,471
Dairy	Flush	Medium1	South	1,346,302
Dairy	Flush	Medium2	Central	1,734,564
Dairy	Flush	Medium2	MidAtlantic	2,142,884
Dairy	Flush	Medium2	MidWest	2,008,119
Dairy	Flush	Medium2	Pacific	2,223,087
Dairy	Flush	Medium2	South	2,055,318
Dairy	Flush	Medium3	Central	2,342,643
Dairy	Flush	Medium3	MidAtlantic	2,883,667
Dairy	Flush	Medium3	MidWest	2,719,159
Dairy	Flush	Medium3	Pacific	2,986,787
Dairy	Flush	Medium3	South	2,731,352
Dairy	Hose	Medium1	Central	454,317
Dairy	Hose	Medium1	MidAtlantic	680,390
Dairy	Hose	Medium1	MidWest	612,546
Dairy	Hose	Medium1	Pacific	730,408
Dairy	Hose	Medium1	South	626,128
Dairy	Hose	Medium2	Central	724,875
Dairy	Hose	Medium2	MidAtlantic	1,068,950

Animal	Type	Size	Region	Storage Volume (cf)
Dairy	Hose	Medium2	MidWest	976,079
Dairy	Hose	Medium2	Pacific	1,117,042
Dairy	Hose	Medium2	South	951,340
Dairy	Hose	Medium3	Central	988,440
Dairy	Hose	Medium3	MidAtlantic	1,446,119
Dairy	Hose	Medium3	MidWest	1,343,209
Dairy	Hose	Medium3	Pacific	1,497,014
Dairy	Hose	Medium3	South	1,270,618

EPA estimated the volume of overflow from a liquid system using the following information:

- Starting volume in pond or lagoon based on wastewater and runoff collected since last land application;
- Change in pond or lagoon volume due to direct precipitation and evaporation[3];
- Change in volume due to runoff from the drylot;
- Change in volume due to estimated daily flow; and
- Change in volume due to pond or lagoon pump-out and/or sludge cleanout and land application.

The net change in the volume of the liquid storage area is calculated daily and added to the previous day's total. If the total volume is greater than the maximum design volume, EPA assumes the excess volume overflows.

The methodology used for estimating overflows from liquid storage systems is presented in the following eight steps (Attachments A and B present full examples of calculating overflow):

1. For each day over the 25-year period, EPA subtracted the evaporation from the precipitation to calculate the net precipitation. EPA multiplied the net precipitation by the pond[4] surface area to get a net precipitation volume for the pond.

   Net Precipitation (in) = Precipitation (in) - Evaporation (in)

   Net Precipitation Volume (cf) = [Net Precipitation (in) * Pond Surface Area (sf)] / 12 (in / ft)]

2. EPA calculated the runoff volume by subtracting the number of inches expected to infiltrate the soil (0.5 inches) from the daily precipitation and multiplying by the drylot runoff area. If precipitation minus the infiltration is less than zero, the runoff is assumed to be zero.

   Runoff Volume (cf) = [Precipitation (in) - Infiltration (in)] * Runoff Area (sf) / 12 (in/ft)

   Where: Infiltration = 0.5 in

3. Next, EPA performed a check to see if land application can occur. For purposes of this analysis, EPA assumes liquid is applied every day during the growing season, as long as there has been no net precipitation during the previous three days.

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[3]Precipitation data from EPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model were used in the analysis.

[4]The term "pond" is used to represent a pond or a lagoon.

If the check for application is "no", go to Step 6.

4. EPA assumed that liquids are land applied to the maximum hydraulic loading rate[5].

   Daily Hydraulic Loading Rate (cf) = [Evapotranspiration Rate (ft) - Precipitation Rate (ft) + Percolation Rate (ft)] x Area Required for Application (sf)

   Daily Application Volume (cf) = Daily Hydraulic Loading Rate (cf)

5. EPA calculated the daily volume of the pond by summing the net precipitation volume, the runoff volume, the estimated daily flow, the previous day's pond volume, and subtracting the daily application volume.

   Daily Pond Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Estimated Daily Flow (cf) + Previous Volume (cf) - Daily Application Volume (cf)

   Skip to Step 7.

6. If the check for application is "no", EPA calculated the new daily volume of the pond by summing the net precipitation volume, the runoff volume, the estimated daily flow, and the previous day's pond volume.

   Daily Pond Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Estimated Daily Flow (cf) + Previous Volume (cf)

7. EPA calculated the pond volume for each day during the 25-year period. When the daily pond volume is greater than the maximum pond volume, EPA assumed an overflow occurs equal to the daily pond volume less the maximum design pond volume. The pond volume is then set equal to the maximum design pond volume.

   Overflow (cf) = Daily Pond Volume (cf) - Maximum Pond Volume (cf)

   Daily Pond Volume (cf) = Maximum Pond Volume (cf)   [if overflow occurs]

8. EPA calculated the annual overflow for each year of the analysis, as well as the median overflow that occurs during the 25-year period. EPA used the median annual overflow to estimate the expected pollutant discharges described in Sections IV and V.

III Estimating Overflow from a Baseline System with No Storage

This section describes EPA's method to determine the number and volume of overflows that would occur from a baseline system with no storage over a 25-year period. EPA estimates the volume of overflow using the following information:

- Volume of daily runoff;
- Volume of daily flow; and
- Maximum hydraulic loading;

During the freeze days for a model farm without storage, EPA assumed that land application of liquid wastes would not occur and that all liquids (daily flow and runoff, if applicable) are overflows resulting in pollutant loadings. During the freeze free days for a model farm without storage, EPA assumed that the daily flow is land applied, up to

[5]ERG. 2001. *Proposed Revision to Liquid Land Application Cost Methodology*. Memorandum prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC. October 2001.

the daily maximum hydraulic loading[6]. EPA also assumed that liquids in excess of the maximum hydraulic loading result in overflow.

The methodology used for estimating overflows from facilities with no storage is presented in the following seven steps (Attachment B presents a full example of calculating overflow):

1. EPA calculated the runoff volume by subtracting the number of inches expected to infiltrate the soil (0.5 inches) from the daily precipitation and multiply by the drylot runoff area. If precipitation minus the infiltration is less than zero, the runoff is assumed to be zero.

   Runoff Volume (cf) = [Precipitation (in) - Infiltration (in)] * Runoff Area (sf) / 12 (in/ft)

   Where: Infiltration = 0.5 in

2. EPA calculated the overflow during the freeze period[7]. For purposes of this analysis, EPA assumds that liquid is not land applied during freeze days. Because there is no liquid storage system in place, all estimated daily flow plus runoff (if applicable) are treated as overflow.

   Daily Overflow (cf) = Estimated Daily Flow (cf / day) + Runoff (cf / day)

3. Next, EPA performed a check to see if the daily flow will be land applied. For purposes of this analysis, EPA assumed liquid is applied every day during the growing season, as long as there has been no net precipitation during the previous three days.

   If the check for application is “no”, go to Step 6.

4. EPA assumed that liquids are land applied to the maximum hydraulic loading rate[8].

   Daily Hydraulic Loading Rate (cf) = [Evapotranspiration Rate (ft) - Precipitation Rate (ft) + Percolation Rate (ft)] x Area Required for Application (sf)

5. If the maximum hydraulic loading rate is less than the estimated daily flow, an overflow occurs.

   If Daily Hydraulic Loading (cf) < Estimated Daily Flow (cf),
   Daily Overflow (cf) = Estimated Daily Flow (cf) - Daily Hydraulic Loading (cf)

   Skip to Step 7.

6. If the check for application is “no”, EPA calculated the daily volume of overflow.

   Daily Overflow (cf) = Estimated Daily Flow (cf) + Runoff (cf)

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[6]EPA assumes that daily land application occurs even though there is no storage system available to temporarily store the waste (eg., daily haul operation).

[7]ERG. 2000. *Methodology for Estimating Storage Requirements for Option 7*. Memorandum prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC. December 2000.

[8]ERG. 2001. *Proposed Revision to Liquid Land Application Cost Methodology*. Memorandum prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC. October 2001.

7. EPA calculated the annual overflow for each year of the analysis, as well as the median overflow that occurs during the 25-year period. EPA used the median annual overflow to estimate the expected pollutant discharges, described in Sections IV and V.

IV Estimating Pollutant Load in Overflow

In this analysis, EPA used the waste characterization data in Table 5 to estimate the median annual pollutant loadings resulting from overflows.

Table 5

Raw Waste Characteristics[9]

Pollutant	Concentration (lb/1,000 gal)	
	Beef and Heifer	Dairy
Nitrogen	1.67	1.67
Phosphorous	0.48	0.48
BOD	2.92	2.92
Fixed Solids	17.5	11.66
Fecal Coliform[1,2]	1.11 x 10^6 colonies	1.35 x 10^8 colonies

[1] Units for fecal coliform are 10^6 Most Probable Number (MPN) per gallon.
[2] Fecal coliform values assume the fixed solids are 100% manure.

EPA multiplied the concentration of each pollutant in the runoff by the volume of overflow determined in Sections II and III to estimate the pollutant loads in the overflow that occur from a baseline or BAT storage system at each model farm.

Pollutant Load (lb/yr) = [Pollutant Concentration in Runoff (lb/1,000 gal) * Median Overflow Volume (gal/yr)]

Attachment C contains the model farm median overflow and resultant pollutant loads results. Tables C-1 through C-4 present the model farm overflow and pollutant loads expected at the production area of beef feedlots, heifer operations, and dairies broken out by animal type, region, size class, and type of liquid storage system. Table C-1 presents the results for Large facilities (with existing storage systems). EPA assumes BAT storage is already in place at baseline (see Table 1); therefore, the pollutant loads for Large operations are the same at baseline and under BAT. Tables C-2 through C-4 present the results for Medium facilities with the following storage systems, respectively: facilities with 180-days of storage, facilities with existing storage, and facilities with no storage in place.

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[9]USDA NRCS. 1992. *Agricultural Waste Management Field Handbook, National Engineering Handbook (NEH)*, Part 651. Tables 4-7 and 4-8. U.S. Department of Agriculture, Natural Resources Conservation Service. (the concentration of phosphorous and BOD was transferred from dairy to beef and heifer, since no data were available).

For the Medium operations, EPA assumes that 50% of beef feedlot and heifer operations, and 90% of dairies have existing storage in place at baseline; EPA assumes that 50% of beef feedlot and heifer operations and 10% of dairies do not have storage at baseline (see Table 1). It is assumed that all dairies without storage at baseline are hose dairies; therefore, all flush dairies have existing storage in place at baseline. EPA assumes that all facilities without storage under baseline are costed by EPA to design a pond or lagoon with 180 days of storage under BAT.

Table C-5 presents the weighted average model farm pollutant loads at baseline. For Large and Medium operations, EPA averaged the resultant pollutant loads for flush and hose dairies, based on the number of flush and hose facilities[10], arriving at the average pollutant loads expected at a dairy. For Medium facilities, EPA also averaged the resultant pollutant loads for facilities with no storage and facilities with existing storage based on the number of facilities with no storage and with existing storage[10], arriving at the average pollutant loads expected at the facility at baseline. EPA estimated the weighted average model farm pollutant loads under BAT using a similar averaging process (assuming the Medium facilities with no storage achieved 180-days of storage). Table C-6 presents the weighted average model farm pollutant loads under BAT.

V Estimating Industry-Level Pollutant Loads Resulting from Overflow at the Production Area

For Large operations, EPA multiplied the pollutant loads that occur from a BAT storage system at each model farm by the number of facilities to obtain the industry-level BAT pollutant loads. Attachment D contains the facility counts used in the industry-level pollutant loads analysis. Table D-1 presents the facility counts for Large operations.

$$\text{Industry BAT Pollutant Load}_{\text{Large}} \text{ (lb/yr)} = \text{Model Farm BAT Pollutant Load (lb/yr)} * \text{\# of Facilities}$$

For Medium operations, EPA performed separate calculations for industry-level baseline and BAT pollutant loads. At baseline, EPA multiplied the pollutant loads that occur from a model farm with no storage system by the number of facilities assumed to have no storage system in place at baseline; and multiplied the pollutant loads that occur from a model farm with existing storage by the number of facilities assumed to have existing storage at baseline. Under BAT, EPA performed the same calculation, replacing the pollutant loads that occur from a model farm with no storage system by the pollutant loads that occur from a model farm with 180-days of storage. Table D-2 presents the facility counts for Medium operations[11].

Industry Baseline Pollutant Load$_{\text{Medium}}$ (lb/yr) = [Model Farm No Storage Pollutant Load (lb/yr) * # of Facilities with No Storage] + [Model Farm Existing Storage Pollutant Load (lb/yr) * # of Facilities with Existing Storage]

Industry BAT Pollutant Load$_{\text{Medium}}$ (lb/yr) = [Model Farm 180-days Storage Pollutant Load (lb/yr) * # of Facilities with 180-days Storage] + [Model Farm Existing Storage Pollutant Load (lb/yr) * # of Facilities with Existing Storage]

Attachment E contains the industry-level pollutant loads results. The total industry-level pollutant loads for Large operations are presented in Table E-1. The total industry-level pollutant loads for Medium operations are presented in Tables E-2 and E-3 for baseline and BAT loads, respectively.

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[10] The facility counts are presented in Tables D-1 and D-2 for Large and Medium operations.

[11] EPA applied the following percentages to the Medium AFO counts to determine the permitted number of CAFOs for each animal type in each region:
Beef: CE-8%, MA-12%, MW-12%, PA-14%, SO-14%
Dairy: CE-20%, MA-55%, MW-45%, PA-10%, SO-35%
Heifer: CE-20%, MW-45%, PA-10%

Attachment A

Example of Overflow From a Large Facility

This attachment presents an example of the overflow methodology using model farm data representing the Beef, Large1 model farm located in the Central Region. For purposes of this example, the following data are assumed[12]:

- The farm is located in Deaf Smith County, Texas.
- Number of head: 1,839 head. [In this analysis, the head count determines the amount of drylot area, and the amount of manure solids in the drylot runoff.]
- Maximum pond volume: 56,668 cubic feet. [In this analysis, the pond volume is based on 50 days of storage.]
- Accumulated solids volume: 1,766 cubic feet.
- Pond surface area: 3,486 square feet.
- Drylot runoff area: 845,940 square feet.

Estimate Overflow from BAT System (Using Section II of the Methodology)

EPA used 25-year daily precipitation and evaporation data from the Amarillo airport weather station to represent the climate of this county. The Amarillo weather station is the closest weather station to Deaf Smith County, TX with readily available 25-year climate data. The Amarillo data used in this analysis are available as part of EPA's Better Assessment Science Integrating point and Nonpoint Sources (BASINS) model. (Additional information on BASINS is found at http://www.epa.gov/OST/BASINS/b3webdwn.htm. State weather data are found at http://www.epa.gov/ost/ftp/basins/wdm_data/.) The Amarillo airport data used in this analysis begins on January 1, 1970 and ends on December 31, 1994.

On January 1, 1970, EPA assumes the volume of waste in the pond is equal to the accumulated solids volume (1,766 cf) and the total available volume is 56,668 cf. EPA assumes that the pond volume is never less than the accumulated solids volume. EPA recognizes that there are times that accumulated solids are removed and more space is available for rainfall and runoff. However, this conservative assumption reserves pond space for the maximum amount of accumulated solids over the storage period.

Accumulation in the lagoon during freeze days

On January 2, 1970, the pond volume for EPA's Beef, Central, Large 1 model farm remains at 1,766 cf because the data set used for this analysis includes no precipitation for this day[13]. The first day with precipitation is January 5, 1970. The Amarillo airport weather station reports 0.02 inches of precipitation and 0.0673 inches of evaporation. The daily pond volume is calculated as:

Daily Pond Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Previous Volume (cf)

Where: Net Precipitation Volume[14] (cf) = (0.02 - 0.0673) * 3,486 / 12 = -13.7 cf = 0

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[12]EPA. 2002. *Cost Methodology Report for Animal Feeding Operations.*

[13]EPA assumes no evaporation because, in this analysis, EPA assumes the pond volume cannot drop below the accumulated solids volume.

[14]Although precipitation occurs, there is still net evaporation. EPA assumes no evaporation because the pond volume cannot drop below the accumulated solids volume.

Runoff Volume = (0.02 - 0.5) * 845,940 / 12 = 0 (note: precipitation - infiltration < 0)
Previous Volume = 1,766
Daily Pond Volume = 0 + 0 + 1,766 = 1,766 cf

Land application during freeze free days

The freeze free period for the Central region is 191 days from April to November. EPA assumes the first day of application for Beef, Central, Large 1 is April 28, 1970. In addition to adding the net precipitation and runoff volume to the previous volume, the application volume is subtracted April 28th and every day afterward during the growing season, unless the net precipitation for the previous three days is greater than zero. When overflow is calculated, the volume of the overflow is subtracted from the previous days pond volume.

On April 28, 1970, there was no precipitation and 0.738 inches of evaporation at the Amarillo weather station.

Daily Pond Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Previous Volume (cf) - Maximum Hydraulic Loading (cf)

Where: Net Precipitation Volume (cf) = (0 - 0.738) * 3,486 / 12 = -2,566 cf
Runoff Volume = (0.0 - 0.5) * 845,940 / 12 = 0 (note: precipitation - infiltration < 0)
Previous Volume = 26,963 cf
Maximum Hydraulic Loading = 9,375 cf
Daily Pond Volume = -2,566 + 0 + 26,963 - 9,375 = 15,022 cf

Table A-1 presents the estimated overflow for each year of the 25-year period (i.e., 1970 through 1994). The maximum annual overflow is estimated as 396,433 cubic feet and the minimum annual overflow is estimated as 4,772 cubic feet. The median overflow is estimated as 102,813 cubic feet.

Estimate Pollutant Loads from BAT System (Using Section V of the Methodology)

EPA multiplied the concentration of each pollutant in the runoff[15] by the volume of overflow to estimate the pollutant loads for this model farm. Table A-2 presents the estimated pollutant load in the median overflow for each pollutant.

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[15]The raw waste characteristics (lb / 1,000 gal) are presented in Table 5 of this memorandum.

Table A-1. Summary of Estimated Overflow from BAT System

Year	Annual Overflow (cf)	
1970	4,772	
1971	136,097	
1972	19,525	
1973	90,297	
1974	281,492	
1975	102,813	Median Value
1976	97,993	
1977	61,673	
1978	396,433	
1979	262,677	
1980	30,014	
1981	41,460	
1982	279,989	
1983	82,394	
1984	272,542	
1985	199,102	
1986	245,537	
1987	48,946	
1988	258,584	
1989	72,627	
1990	190,290	
1991	21,055	
1992	208,619	
1993	129,675	
1994	79,932	

Table A-2. Pollutant Load in Median Overflow (lb/yr)

Pollutant	Load (lb/yr)
Nitrogen	1,284
Phosphorus	369
BOD	2,246
Fixed Solids	13,459
Fecal Coliform*	328,972

* Units are million colonies/yr

Attachment B

Example of Overflow From a Medium Facility

This attachment presents an example of the methodologies used to estimate overflow from the Dairy-Hose, Medium1 model farm located in the Central Region under the following scenarios: BAT storage (180-days), existing storage (60-days), and no storage. For purposes of this example, the following data are assumed[16]:

- The farm is located in Erath County, Texas.
- Number of head: 250 head. [In this analysis, the head count determines the amount of drylot area, and the amount of manure solids in the drylot runoff.]
- Drylot runoff area: 51,750 square feet.
- Number of freeze free days: 226
- Estimated Daily Flow: 245 cubic feet

Facilities with no storage (10% of facilities at baseline):

- Maximum lagoon volume: N/A.
- Lagoon surface area: N/A.
- Accumulated solids volume + sludge volume: N/A.

Facilities with 180-days of storage (10% of facilities under BAT):

- Maximum lagoon volume: 454,317 cubic feet.
- Lagoon surface area: 36,289 square feet.
- Accumulated solids volume + sludge volume: 312,841 cubic feet.

Facilities with existing storage, based on 60-days of storage (90% of facilities at baseline and under BAT):

- Maximum lagoon volume: 355,877 cubic feet.
- Lagoon surface area: 31,447 square feet.
- Accumulated solids volume + sludge volume: 295,531 cubic feet.

Estimating Overflow from a Medium Facility

EPA used 25-year daily precipitation and evaporation data from the Waco airport weather station to represent the climate of this county. The Waco weather station is the closest weather station to Erath, TX with readily available 25-year climate data. The Waco data used in this analysis are available as part of EPA's Better Assessment Science Integrating point and Nonpoint Sources (BASINS) model. (Additional information on BASINS is found at http://www.epa.gov/OST/BASINS/b3webdwn.htm. State weather data are found at http://www.epa.gov/ost/ftp/basins/wdm_data/.) The Waco airport data used in this analysis begins on January 1, 1970 and ends on December 31, 1994.

[16]EPA. 2002. *Cost Methodology Report for Animal Feeding Operations.*

EPA assumed that 90% of the total Medium dairies have existing storage at baseline (including 100% of the flush facilities). These facilities will retain their existing storage under BAT. EPA also assumed that 10% of the total Medium dairies do not have storage at baseline (all are assumed to be hose facilities). These “no storage” dairies achieve 180-days of storage under BAT. Therefore, to estimate the industry level overflow volume and pollutant loads for Medium dairies at baseline and under BAT, EPA examined three different scenarios: dairies with BAT storage, dairies with existing storage, and dairies with no storage.

Dairies with 180-days Storage (Using Section II of the Methodology):

On January 1, 1970, EPA assumes the volume of waste in the lagoon is equal to the accumulated solids and sludge volume (312,841 cf) plus the estimated daily flow accumulated since the last day of application (17,395 cf).

Estimated Daily Flow Accumulated (cf) = Estimated Daily Flow (cf) x Days Since Last Application
Where: Estimated Daily Flow = 245 cf
Days Since Last Application = 71 days

The total available storage volume is 454,317 cf. EPA assumes that the lagoon volume is never less than the accumulated solids and sludge volume. EPA recognizes that there are times that accumulated solids and sludge are removed and more space is available for rainfall and runoff. However, this conservative assumption reserves lagoon space for the maximum amount of accumulated solids and sludge over the storage period.

Accumulation in the lagoon during freeze days

The first day with precipitation for EPA’s Dairy, Central, Medium 1 model farm is January 2, 1970. The Waco airport weather station reports 0.06 inches of precipitation and 0.0323 inches of evaporation.

The daily lagoon volume is calculated as:

Daily Lagoon Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Estimated Daily Flow (cf) + Previous Volume (cf)

Where: Net Precipitation Volume (cf) = (0.06 - 0.0323) * 36,289 / 12 = 83.8 cf

Runoff Volume = (0.06 - 0.5) * 51,750 / 12 = 0 (note: precipitation - infiltration < 0)

Estimated Daily Flow = 245 cf

Previous Volume = 312,841 + 17,395 = 330,236 cf

Daily Lagoon Volume = 83.8 + 0 + 245 + 330,236 = 330,565 cf

Land application during freeze free days

The freeze free period for the Central region is 226 days from March to October. EPA assumes the first day of application for Dairy-Hose, Central, Medium 1 is March 10, 1970. In addition to adding the net precipitation, runoff volume, and separated flow volume to the previous volume, the application volume is subtracted March 10th and every day afterward during the growing season, unless the net precipitation for the previous three days is greater than zero. When overflow is calculated, the volume of the overflow is subtracted from the previous days lagoon volume.

On March 10, 1970, there was 0.17 inches of precipitation and 0.142 inches of evaporation at the Waco weather station.

Daily Lagoon Volume (cf) = Net Precipitation Volume (cf) + Runoff Volume (cf) + Estimated Daily Flow (cf) + Previous Volume (cf) - Daily Maximum Hydraulic Loading (cf)

Where: Net Precipitation Volume (cf) = (0.17 - 0.142) * 36,289 / 12 = 84.7 cf

Runoff Volume = (0.17 - 0.5) * 51,750 / 12 = 0 (note: precipitation - infiltration < 0)

Estimated Daily Flow = 245 cf

Previous Volume = 332,692 cf

Daily Maximum Hydraulic Loading = 606 cf

Daily Lagoon Volume = 84.7 + 0 + 332,692 - 606 = 332,865 cf

Table B-1 presents the estimated overflow for each year of the 25-year period (i.e., 1970 through 1994). This model farm is expected to have zero overflows (and therefore zero pollutant loadings from overflows) during the 25-year time period.

Dairies with Existing Storage:

The same general methodology outlined for dairies with 180-days storage is used for dairies with existing storage. The farm location and corresponding climate data, the number of head, the drylot runoff area, and the estimated daily flow are the same as the 180-days storage example; the maximum lagoon volume and surface area, and the accumulated solids volume and sludge volume are different than the 180-days storage example.

Table B-2 presents the estimated overflow for each year of the 25-year period (i.e., 1970 through 1994). The maximum annual overflow is estimated as 43,419 cubic feet and the minimum annual overflow is estimated as 0 cubic feet. The median overflow is estimated as 0 cubic feet.

Facilities with No Storage (Using Section III of the Methodology):

The following example demonstrates how EPA estimated the daily overflow volume or land application volume for a dairy with no storage under these scenarios: freeze days, freeze free days (with and without precipitation), and freeze free days with low maximum hydraulic loading.

Overflow during freeze days

During the freeze days for this model farm (October 22 through March 9), EPA assumes that land application of liquid wastes does not occur. Since there is no lagoon for storing the estimated daily flow or runoff (if applicable), it is assumed that all liquids are overflows resulting in pollutant loadings during this time.

The first day with precipitation for EPA's Dairy, Central, Medium 1 model farm is January 2, 1970. The Waco airport weather station reports 0.06 inches of precipitation and 0.0323 inches of evaporation. The overflow volume is calculated as:

Daily Overflow Volume (cf) = Runoff Volume (cf) + Estimated Daily Flow (cf)

Where: Runoff Volume (cf) = (0.06 - 0.5) * 51,750 / 12 = 0 (precipitation - infiltration < 0)

Estimated Daily Flow (cf) = 245 cf

Daily Overflow Volume (cf) = 0 + 245 = 245 cf

Land application during freeze free days

The freeze free period for the Central region is 226 days from March to October. EPA assumes the first day of application for Dairy-Hose, Central, Medium 1 is March 10, 1970. The Waco airport weather station reports 0.17 inches of precipitation and 0.142 inches of evaporation. Because there is no net precipitation (minus infiltration), there is no runoff volume. EPA assumes that liquids are land applied to the maximum hydraulic loading rate[17]. Since the estimated daily hydraulic loading for March 10 is 606 cubic feet, and the estimated daily flow is 245 cubic feet, all liquids are land applied and no overflow occurs.

Daily Volume Land Applied (cf) = Estimated Daily Flow (cf) = 245 cf

Overflow during freeze free days with precipitation

On March 16, the Waco airport weather station reports 0.7 inches of precipitation and 0.0341 inches of evaporation. Because there is net precipitation (minus infiltration), EPA assumes application will not occur over the next three days. The daily overflow is estimated:

Daily Overflow Volume (cf) = Runoff Volume (cf) + Daily Liquid for Application (cf)
Where: Runoff Volume (cf) = (0.7 - 0.5) * 51,750 / 12 = 863 cf
Daily Liquid for Application (cf) = 245 cf
Daily Overflow Volume (cf) = 863 + 245 = 1,108 cf

Overflow when maximum hydraulic loading is exceeded

On April 18, the maximum hydraulic loading is 166 cubic feet. This volume is less than the estimated daily flow (245 cubic feet); therefore, an overflow occurs.

Daily Volume Land Applied (cf) = Max Hydraulic Loading = 166 cf

Daily Overflow Volume (cf) = Estimated Daily Flow - Max Hydraulic Loading = 245 - 166 = 79 cf

Table B-3 presents the estimated overflow for each year of the 25-year period (i.e., 1970 through 1994). The maximum annual overflow is estimated as 165,058 cubic feet and the minimum annual overflow is estimated as 24,320 cubic feet. The median overflow is estimated as 72,421 cubic feet.

EPA multiplied the concentration of each pollutant in the runoff[18] by the volume of overflow to estimate the pollutant loads for this model farm. Table B-4 presents the estimated pollutant load in the median overflow for each pollutant.

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[17]ERG. 2001. *Proposed Revision to Liquid Land Application Cost Methodology*. Memorandum prepared for U.S. Environmental Protection Agency, Office of Water, Washington, DC. October 2001.

[18]The raw waste characteristics (lb / 1,000 gal) are presented in Table 5 of this memorandum.

Table B-1. Summary of Estimated Overflow from 180-day Storage System

Year	Annual Overflow (cf)
1970	0
1971	0
1972	0
1973	0
1974	0
1975	0
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0
1982	0
1983	0
1984	0
1985	0
1986	0
1987	0
1988	0
1989	0
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0

Table B-2. Summary of Estimated Overflow from an Existing Storage System

Year	Annual Overflow (cf)
1970	0
1971	1,647
1972	374
1973	5,530
1974	30,202
1975	33,205
1976	0
1977	0
1978	0
1979	0
1980	0
1981	0
1982	0
1983	0
1984	28,653
1985	0
1986	3,944
1987	0
1988	0
1989	0
1990	0
1991	8,149
1992	43,419
1993	8,423
1994	0
1995	6,462

Table B-3. Summary of Estimated Overflow from a Facility with No Storage

Year	Annual Overflow (cf)
1970	53,879
1971	71,252
1972	70,439
1973	165,058
1974	89,653
1975	117,279
1976	132,966
1977	50,909
1978	24,320
1979	136,135
1980	37,487
1981	105,301
1982	70,260
1983	31,859
1984	67,315
1985	106,143
1986	84,083
1987	73,591
1988	64,881
1989	68,586
1990	101,070
1991	101,862
1992	46,928
1993	88,515
1994	61,794
1995	136,400

Table B-4. Pollutant Load in Median Overflow (lb/yr)

Pollutant	Load (lbs/yr)
Nitrogen	905
Phosphorus	260
BOD	1,582
Fixed Solids	6,317
Fecal Coliform*	73,106

Appendix C. Estimating Potential Overflows and Resultant Pollutant Loads from Swine and Poultry—Wet Layers Production Areas

To: CAFO Record
From: Brent Kurapatskie and Jed Waddell, Tetra Tech, Inc.
Subject: Estimating Potential Overflows and Resultant Pollutant Loads from Swine and Poultry—Wet Layers Production Areas
Date: December 05, 2002

This memorandum describes the methodology developed by Tetra Tech to estimate the pollutant loads from swine and poultry liquid containment systems that occur over a 30-year period. Tetra Tech used this methodology to estimate the overflows from liquid containment systems attributed to improper management, daily precipitation, and other variables. Furthermore, Tetra Tech coupled the estimated overflows with animal-specific pollutant characterization to predict the mass pollutant discharge for each facility. Finally, the estimated mass pollutant discharges were weighted and used to estimate the total industry pollutant loadings for swine and poultry-wet layers liquid containment systems.

This memorandum presents the following sections of the methodology:

- Section I describes the estimation of the volume of overflow from a liquid containment system (lagoon systems).
- Section II describes the development of the total industry volume of discharge associated with the swine and poultry sectors.
- Section III describes the use of waste characterization data to estimate the pollutant loads in the overflow from swine and poultry-wet layers sectors.
- Section IV describes the development of the total industry pollutant loads for the swine and poultry-wet layers sectors.

Section I. Methodology for the Estimation of the Overflow Volumes from Swine and Poultry Liquid Containment Systems

The lagoon model spreadsheet contains more than 8,000 rows of data recorded from various sites around the United States that were used to calculate the amount of liquid discharged from a lagoon on an animal unit (AU) per daily basis, by using the following mass balance equation (Equation 1):

Equation 1: *Freeboard –[(Precipitation + Flush Water + Runoff) – (Evapotranspiration and Land Application)] = Overflow of the lagoon*

As shown, the mass balance equation contains five key variables (three input variables and two output variables).

Input Variables:

- Precipitation (in). Tetra Tech used more than 20 years of daily precipitation values for the study.
- Runoff (in). This variable represents the runoff of precipitation from the surrounding areas.
- Flush Water (in). This variable represents the amount of water discharged during the normal operation of the business.

Output Variables:

- Evaporation (in). This variable represents the evaporation rate.
- Land Application (in). This variable represents the average amount of animal waste taken from the lagoon and land applied.

Thereby, based on Equation 1 Tetra Tech created the following spreadsheet (Table 1) to calculate the daily discharges from a hypothetical lagoon system.

Table 1. Example of the Lagoon Model Spreadsheet

	Inputs			Outputs				
Freeboard (in)	Precipitation (in)	Flush Water (in)	Runoff (in)	Evaporation (in)	Land Application (in)	Balance (in)	Remaining Freeboard (in)	Discharge (in)
19.0000	0.1890	1.6000	0.0000	0.0102	0.0000	1.7788	17.2200	0.0000

Tetra Tech estimated the volume of overflow from a lagoon system using the following information:

- The freeboard depth was determined to be 19 inches (12 inches of additional storage and 7 inches of storage for the 25-year 24-hour storm event [NOAA, Technical Paper No. 40, http://www.erh.noaa.gov/er/hq/Tp40s.htm]).
- The precipitation and evaporation data are based on actual conditions and were obtained from monitoring stations throughout the United States (www.epa.gov/basins/wdm).
- The amount of runoff entering the lagoon was estimated to be zero, since a properly designed lagoon would contain berms to divert all runoff from entering the lagoon.
- The amount of flush water entering the lagoon was estimated by converting the volume of manure produced by an animal unit (AU) (swine or poultry-wet layer) on a daily basis (lb/AU day) to a daily depth amount (0.8 in/day). For this calculation the lagoon was estimated to have a depth of 12 feet and to be cylindrical.
- The amount of waste taken from the lagoon to be land applied was estimated to be approximately 2 inches per day. In turn, no land application occurred on days in which precipitation was received, and no land application occurred on days where the previous three days had received any precipitation. Furthermore, land application occurred only during the freeze-free period.

It is important to note that the liquid surface level of each lagoon was estimated to be at the base of the freeboard depth (meaning the lagoon would have to fill an additional 19 inches before any discharge would occur).

As shown in Table 1, the net change in the volume of the lagoon is calculated daily and added to the previous day's total. If the total volume is greater than the maximum design volume, Tetra Tech then assumes the excess volume overflows. In turn, each of the daily excess volume overflows was summed over the modeling period, converted to gallons and then divided by the number of modeling years to determine the estimated gallons discharged per year for each sector (swine or poultry-wet layers).

Section II. Total Volume of Overflows for the Swine and Poultry-Wet Layer Industries

To determine the total volume of overflows for the swine and poultry-wet layer industries, Tetra Tech performed the following five steps:

1. Using the total number of swine and/or poultry-wet layer facilities per region (Mid Atlantic, South, Central, Midwest, North, and Pacific), Tetra Tech determined the number of facilities with lagoons designed to hold less than 6 months of storage capacity (based on applicable frequency factors).

2. Tetra Tech calculated the number of AUs per operating facility

3. Tetra Tech multiplied the average number of AU per operating facility by the number of facilities with improperly designed lagoons to get the average number of AUs at operations with improperly designed lagoons.

4. Tetra Tech multiplied the average number of AUs at operations with improperly designed lagoons by the annual

gallons discharged per AU to obtain the average gallons of overflow from facilities with lagoons designed to hold less than 6 months of storage capacity.

5. Finally, Tetra Tech multiplied the average gallons of overflow from facilities with lagoons designed to hold less than 6 months of storage capacity by their relative frequency factor to obtain a regional total volume of overflows for the swine and poultry-wet layer industries.

Table 2 presents an example of the spreadsheet calculations used to calculate the total volume (gallons) of overflows occurring for swine facilities in the Mid Atlantic Region.

Section III. Waste Characterization Data for Swine and Poultry -Wet Layer Operations

In this analysis, Tetra Tech used the waste characterization data in Table 3 to estimate the loadings resulting from overflows.

Section IV. Estimating Total Pollutant Loads from Overflows for the Swine and Poultry-Wet Layer Industries

For this analysis, Tetra Tech multiplied the regional total volume of overflows for the swine and poultry-wet layer industries by each industries' respective waste characteristics to determine the total pollutant loads from overflows at swine and poultry-wet layer industries on a regional basis (Table 4).

Table 2. Sample Spreadsheet Calculation for Swine Operations in the MidAtlantic Region

Animal	Operation	region	storage	5-Medium1	4-Medium2	3-Medium3	2-Large1	1-Large2	Total	% of Operations
Swin	FF	MA	liq	294.72	209.44	101.95	267.08	191.57	1,064.77	75%
Swin	GF	MA	liq	136.63	123.76	73.58	224.68	161.16	719.82	
Swin	FF	MA	pit	49.58	35.23	17.15	83.88	60.17	246.01	25%
Swin	GF	MA	pit	48.76	44.17	26.26	134.81	96.70	350.68	
									2,381.28	
Percentage of Operations with Storage Less Than 6 Months										
Animal	Operation	region	storage	5-Medium1	4-Medium2	3-Medium3	2-Large1	1-Large2		
Swin	FF and GF	MA	liq	28%	26%	24%	21%	15%		
Number of Operations in the MidAtlantic Region with Storage Less Than 6 Months										
Animal	Operation	region	storage	5-Medium1	4-Medium2	3-Medium3	2-Large1	1-Large2	Total	
Swin	FF	MA	liq and pit	96.40	63.62	28.58	73.70	37.76	300	
Swin	GF	MA	liq and pit	51.91	43.66	23.96	75.49	38.68	234	
Total				148	107	53	149	76	534	22.42%
Facilities that can land application < 2 Inches/ 3 day period (approximately 10 percent of the operations with less than 6 month storage										
Animal	Operation	region	storage	5-Medium1	4-Medium2	3-Medium3	2-Large1	1-Large2	Total	
Swin	FF	MA	liq and pit	9.64	6.36	2.86	7.37	3.78	30	
Swin	GF	MA	liq and pit	5.19	4.37	2.40	7.55	3.87	23	
Total				15	11	5	15	8	53	2.24%
				AU (300-500)	AU (500-750)	AU (750-1000)	AU (1000-2000)	AU (+2000)		
Average Gallons Discharged per Operation, Annually*			FF, MA	888,925	1,595,021	2,274,849	3,687,042	17,986,545		
			GF, MA	1,011,861	1,598,174	2,294,813	3,734,325	9,344,219		
*Based on An Average of 2627 Gallons Discharged per AU multiplied by the average number of AUs per size class										
Total Gallons Discharged Annually, by Operations in the MidAtlantic Region with Storage Less Than 6 Months										
Animal	Operation	region	storage	5-Medium1	4-Medium2	3-Medium3	2-Large1	1-Large2	Total	
Swin	FF	MA	liq and pit	8,569,639	10,146,751	6,502,646	27,174,196	67,918,967	**120,312,199**	
Swin	GF	MA	liq and pit	5,252,585	6,977,891	5,498,583	28,191,250	36,141,811	**82,062,120**	

Table 3. Waste Characteristics

Units lbs/1000 gal*

Component	Swine	Poultry-Wet Layers
Nitrogen[1]	2.91	6.25
Phosphorus[1]	0.63	0.83
BOD[1]	3.33	3.70
Solids[1]	0.25 (% w.b.)	25 (% w.b.)
Fecal Coliform[2]	100*Phosphorus	28*Phosphorus
Fecal Strep[2]	2944*Phosphorus	53.333*Phosphorus
Zinc[2]	0.02778*Phosphorus	0.06333*Phosphorus
Copper[2]	0.0066667*Phosphorus	0.0027667*Phosphorus
Cadmium[2]	0.00015*Phosphorus	0.00012667*Phosphorus
Nickel[2]	0.000441*Phosphorus	0.000833*Phosphorus
Lead[2]	0.000467*Phosphorus	0.002467*Phosphorus
Arsenic[2]	0.003836*Phosphorus	0.000457*Phosphorus

*Unless otherwise noted

[1]Source: NRCS. 1996. National Agricultural Waste Management Field Handbook. United States Department of Agriculture, Washington DC.

[2] Source: Tetra Tech. 2000. Cost Methodology for the Swine and Poultry Industry.

Table 4. Example of Pollutant Loads from Overflows at Swine Operations in the Mid-Atlantic Region

Operation	Size	Region	Nitrogen	Phosphorus	BOD	Solids	Fecal Coliform	Fecal Strep	Zn	Cu	Cd	Ni	Pb	As
GF	M1	MA	342.38	74.12	392.07	29.43	7412.45	218255.42	2.06	0.49	0.01	0.03	0.03	0.28
GF	M2	MA	454.85	98.47	520.85	39.10	9847.20	289945.31	2.74	0.66	0.01	0.04	0.05	0.38
GF	M3	MA	358.42	77.60	410.43	30.81	7759.60	228477.14	2.16	0.52	0.01	0.03	0.04	0.30
GF	L1	MA	1837.62	397.83	2104.27	157.98	39783.49	1171402.81	11.05	2.65	0.06	0.18	0.19	1.53
GF	L2	MA	2355.87	510.03	2697.73	202.53	51003.32	1501764.53	14.17	3.40	0.08	0.23	0.24	1.96

Appendix D.

Selection of Cropping Practices

To: George Townsend
From: Jon Harcum
Subject: Selected County Cropping Practices
Date: February 13, 2002

This memorandum summarizes the phone call survey to selected counties regarding predominant crops used for manure disposal. For each county contacted, the county agent and date are recorded along with a summary of their input. I am awaiting call backs from some contacts.

ST	County	Label	FIPS	Beef	Dairy	Broilers	Layers	Turkey	Swine
AL	Cullman	Cullman County, AL	01043			1	1		
Cullman County CES (256) 737-9386			Greg Hodges (2/11): forage (bermuda, some fescue)						
AR	Benton	Benton County, AR	05007			1			
ALREADY DONE			ALREADY DONE						
AR	Franklin	Franklin County, AR	05047					1	
Franklin County CES/Ozark Office (501) 667-3720			Bob Rhodes (2/4): pasture (native, bermuda, fescue) following guidelines drawn up by NRCS plans, very little goes to row crops						
AR	Sevier	Sevier County, AR	05133						1
Sevier County CES (870) 584-3013			Ralph Tyler (2/4): Pretty much all goes on hayland such as bermuda, fescue, or rye.						
AR	Washington	Washington County, AR	05143				1		
Washington County CES (501) 444-1755			Merle Gross (2/5): pasture (primarily bermuda and fescue, some double cropped w/ wheat or rye on bermuda) small amount on bermuda; no row crops						
CA	Fresno	Fresno County, CA	06019			1		1	
ALREADY DONE			ALREADY DONE						
CA	Riverside	Riverside County, CA	06065				1		
Riverside County CES (909) 683-6491			Jose Aguiar 760.863.7949 (no information received)						
CA	Tulare	Tulare County, CA	06107		1				1
GA	Franklin	Franklin County, GA	13119			1			
Franklin County CES (706) 384-2843			Ricky Josey (2/4): permanent pasture (native grasses and bermuda) to go along with cattle operations, 2-3 tons/acre is common, very little row crops						
GA	Jackson	Jackson County, GA	13157				1		
Jackson County CES (706) 367-6346			Mark Shirley (2/4): forage (hybrid bermuda grasses), a possibility of wheat and rye as overseeded on bermuda grasses.						
IL	Henry	Henry County, IL	17073						1
Henry County CES (309) 853-1533			Dale Baird (2/5): corn/soybean rotation; some continuous corn						
IN	Carroll	Carroll County, IN	18015						1
Carrol County Extension (765) 564.3169			Steve Nichols (2/4): majority of operations are deep pits with a few lagoons; many operations can go to fall injection after crop removal although those with less storage may spring inject or frozen ground apply. Frozen ground is done to						

ST	County	Label	FIPS	Beef	Dairy	Broilers	Layers	Turkey	Swine
			prevent compaction. The vast majority of operations use corn/soybean rotation. Some have winter wheat.						
IN	Dubois	Dubois County, IN	18037					1	
Dubois County Extension (812) 482.1782			Jim Peter (2/4): 70-80% split evenly between continuous corn and corn/soybean/wheat rotation; remainder is some pasture and hay ground (mostly kentucky 31 fescue)						
IN	Lagrange	Lagrange County, IN	18087				1		
Lagrange County Extension (260) 499.6334			Steve Engleking (2/4): split between Amish and English operations, possible a few more Amish operations that would use a corn/small grain/hay rotation (hay: grass/legume or orchard grass) than English operations that would use corn/ soybeans/ small grain rotation; both might go 1 or 2 years of corn and may not use the hay or small grain in rotation.						
IA	Clay	Clay County, IA	19041				1		
Clay County CES (712) 262-2264			Paul Kassel (2/5): corn/soybean rotation (usually applied in bean stubble ahead of corn crop						
IA	Sioux	Sioux County, IA	19167						1
ALREADY DONE			ALREADY DONE						
MD	Wicomico	Wicomico County, MD	24045			1			
ALREADY DONE			ALREADY DONE						
MN	Kandiyohi	Kandiyohi County, MN	27067					1	
Kandiyohi County CES (320) 231-7890			Pat Kearney (2/6): Most is applied corn/soybean rotation or corn/sugar beet rotation. For corn/soybean rotation, manure is typically stockpiled outside for a few months and applied on soybean stubble in the fall and incorporated within 48 hours. FYI: Kandiyohi english translation is land of buffalo fish.						
MN	Martin	Martin County, MN	27091						1
Martin County CES (507) 235-3341			William Crawford (2/5): corn/soybeans (most all of southern MN)						
MS	Scott	Scott County, MS	28123			1			
Scott County CES (601) 469-4241			Dedric Brown (2/5): predominately pasture (bermuda, rye, bahia grass, some fescue); rarely used on row crops						
MO	Barry	Barry County, MO	29009			1			
ALREADY DONE			ALREADY DONE						
MO	Morgan	Morgan County, MO	29141					1	
Morgan County CES (573) 378-5358			Tim Schnakenberg (2/6): majority of litter (~3/4) is on hay/pasture (fescue), and some corn; to the north there is some significant corn land (these counties also have significant turkey operations)						
MO	Vernon	Vernon County, MO	29217						1
Vernon County CES (417) 448-2560			Patricia Miller (2/5): no real dominant practice, most will pump to alfalfa, corn, or fescue; corn may be rotated out with soybeans						
NE	Cuming	Cuming County, NE	31039	1					1
(402) 372-6006			Larry Howard (2/12): Both beef and swine operations will generally use corn/soybean rotation, some will include alfalfa as an alternative						
NC	Duplin	Duplin County, NC	37061					1	1

<table>
<tr><th>ST</th><th>County</th><th>Label</th><th>FIPS</th><th>Beef</th><th>Dairy</th><th>Broilers</th><th>Layers</th><th>Turkey</th><th>Swine</th></tr>
<tr><td colspan="3">ALREADY DONE</td><td colspan="7">ALREADY DONE</td></tr>
<tr><td>NC</td><td>Nash</td><td>Nash County, NC</td><td>37127</td><td></td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td colspan="3">Nash County CES
(252) 459.9810</td><td colspan="7">Mike Wilder (2/7): suggested sweat potatoes, tabacco, wheat, and rye; but suggested calling R. Manning (see below)
Randy Manning (252.459.7567, private contractor, left message 2/7, no information received)</td></tr>
<tr><td>NC</td><td>Wilkes</td><td>Wilkes County, NC</td><td>37193</td><td></td><td></td><td>1</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Wilkes County CES
(336) 651-7330
(336) 651-7331</td><td colspan="7">Matt Miller (2/7): Primarily forage/pasture (fescue, orchard grass, kentucky blue grass); followed by corn as a strong second; fair amount of broiler manure going out as cattle feed to VA and KY</td></tr>
<tr><td>OH</td><td>Mercer</td><td>Mercer County, OH</td><td>39107</td><td></td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td colspan="3">Mercer County CES
(419) 586-2179</td><td colspan="7">Joe Beiler (2/7): a fair amount of manure is moving off-farm northward; but otherwise applied to corn/soybean rotation</td></tr>
<tr><td>OK</td><td>Texas</td><td>Texas County, OK</td><td>40139</td><td>1</td><td></td><td></td><td></td><td></td><td>1</td></tr>
<tr><td colspan="3">Texas County CES
(580) 338-7300</td><td colspan="7">Steve Kraich (2/7):
beef: predominantly continuous corn; secondarily wheat, grain sorghum; mostly irrigated acres and some dry land
swine: predominantly continuous corn mixed in with irrigation water; some manure put on dry land wheat/sorghum/fallow 3-year rotation</td></tr>
<tr><td>PA</td><td>Adams</td><td>Adams County, PA</td><td>42001</td><td></td><td></td><td></td><td></td><td>1</td><td></td></tr>
<tr><td colspan="3">Adams County CES
(717) 334-6271 forwarded to agronomy team in Dawson county (717) 921-8803</td><td colspan="7">Paul Craig (2/7 left message, left message 2/13, no information received)
John Rowehl (717) 240.6500</td></tr>
<tr><td>PA</td><td>Lancaster</td><td>Lancaster County, PA</td><td>42071</td><td>1</td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td colspan="3">ERG DOING</td><td colspan="7"></td></tr>
<tr><td>SC</td><td>Kershaw</td><td>Kershaw County, SC</td><td>45055</td><td></td><td></td><td></td><td></td><td>1</td><td></td></tr>
<tr><td colspan="3">Kershaw County CES
(803) 432-9071</td><td colspan="7">Andy Rawlings (2/13): mostly pasture (common bermuda, coastal bermuda)</td></tr>
<tr><td>TX</td><td>Gonzales</td><td>Gonzales County, TX</td><td>48177</td><td></td><td></td><td></td><td>1</td><td>1</td><td></td></tr>
<tr><td colspan="3">Gonzales County CES
(830) 672-8531</td><td colspan="7">Dwight Sexton -left message (2/1), left another message on 2/13) not likely to call back until 2/19, no information received)</td></tr>
<tr><td>TX</td><td>Shelby</td><td>Shelby County, TX</td><td>48419</td><td></td><td></td><td>1</td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Shelby County CES
(936) 598-7744</td><td colspan="7">ALREADY DONE
James Greer, County Extension Agent (2/1/02)
-Most manure is applied to a variety of bermuda grasses at an application rate of 2-3 tons per acre.
-Some manure is used on pine plantation at 2-3 tons per acre and some ~10% goes to vegetable crops</td></tr>
<tr><td>VA</td><td>Rockingham</td><td>Rockingham County, VA</td><td>51165</td><td></td><td></td><td>1</td><td></td><td>1</td><td></td></tr>
<tr><td colspan="3">Rockingham County CES
(540) 564-3080</td><td colspan="7">Eric Bendfeldt (2/7): predominately corn/rye rotation, some small grain rye, some pasture rye, some to alfalfa hay</td></tr>
</table>