Attachment 19:

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Receiving Animal Wastes
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Hormone Discharges from a Midwest Tile-Drained Agroecosystem Receiving Animal Wastes

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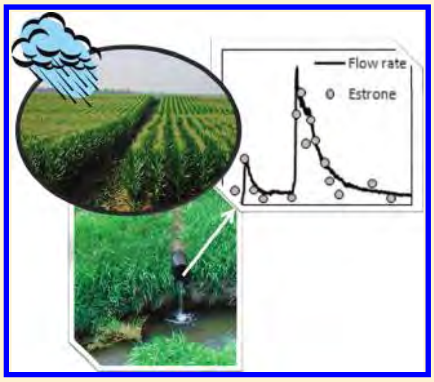
Supporting Information

ABSTRACT: Manure is increasingly being viewed as a threat to aquatic ecosystems due to the introduction of natural and synthetic hormones from land application to agricultural fields. In the Midwestern United States, where most agricultural fields are tile-drained, there is little known about hormone release from fields receiving animal wastes. To this end, seven sampling stations (four in subsurface tile drains and three in the receiving ditch network) were installed at a Midwest farm where various types of animal wastes (beef, dairy, and poultry lagoon effluent, dairy solids, and subsurface injection of swine manure) are applied to agricultural fields. Water flow was continuously monitored and samples were collected for hormone analysis during storm events and baseline flow for a 15 month study period. The compounds analyzed included the natural hormones 17α- and 17β-estradiol, estrone, estriol, testosterone, and androstenedione and the synthetic androgens 17α- and 17β-trenbolone and trendione. Hormones were detected in at least 64% of the samples collected at each station, with estrone being detected the most frequently and estriol the least. Testosterone and androstendione were detected more frequently than synthetic androgens, which were detected in fewer than 15% of samples. Hormone concentrations in subsurface tile drains increased during effluent irrigation and storm events. Hormones also appeared to persist over the winter, with increased concentrations coinciding with early thaws and snowmelt from fields amended with manure solids. The highest concentration of synthetic androgens (168 ng/L) observed coincided with a snowmelt. The highest concentrations of hormones in the ditch waters (87 ng/L for total estrogens and 52 ng/L for natural androgens) were observed in June, which coincides with the early life stage development period of many aquatic species in the Midwest.



INTRODUCTION

Estrogenic and androgenic compounds have been detected in surface waters around the world.[1−3] Humans and livestock are important sources of these compounds with major inputs to the environment including discharge from wastewater treatment plants, combined sewer overflows, and the land application of biosolids and animal wastes. The increasing size of concentrated (or confined) animal feeding operations (CAFOs) has led to manure generation at a higher mass per unit area.[4] Additionally, the amount of estrogens introduced into the environment from land application of animal wastes has been estimated to be >200 times the amount introduced from biosolids applications,[5,6] thereby increasing the potential of CAFOs to be a significant source of hormones to the environment.

Hormones associated with livestock are introduced into the environment when animal wastes are applied to agricultural fields as a nutrient source. The type and amount of hormones in these wastes vary by animal, reproductive stage, and treatment with growth-promoting compounds. Cattle excrete the majority of hormones in feces, whereas poultry and swine excrete the majority of estrogens in urine.[7] 17α-Estradiol (17α-E2) constitutes approximately 60% of estrogens in cattle feces,[1] whereas 17β-E2 and the E2 metabolite estrone (E1) comprise the majority of estrogens in poultry and swine excretions, respectively.[7] Although few studies have focused on the excretion of natural androgens by livestock, Lange et al.[5] estimated that livestock in the United States excrete 4.4 tonnes of androgens each year, with laying hens and cattle (calves and bulls) as the largest sources. Cattle receiving growth-promoting ear implants containing 17β-trenbolone acetate (TBA) excrete the synthetic androgens 17β-trenbolone (17β-TB), trendione (TND), and 17α-trenbolone (17α-TB), with the majority being excreted within the first 5 weeks after implant;[8] thus, their input into the environment is not as consistent as that of natural hormones.

Various laboratory and field studies have been conducted to assess the potential impact of CAFOs on nearby waterways. In laboratory studies, the parent hormones (e.g., E2, TB, and testosterone) have exhibited relatively short half-lives in aerobic soils and manure-amended soils on the order of a few days,[9] leading to hypotheses that hormone discharge to surface water and groundwaters should be minimal. However, Kjær et al.[10] observed hormone concentrations in tile drainage up to 11 months after subsurface injection of liquid swine manure during a 1 year

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study period. They suggested that soil temperature fluctuations and preferential flow through soil macropores may play important roles in explaining the different observations between field and laboratory studies.

Hormones are known to cause endocrine disruption in sensitive aquatic organisms at low nanograms per liter levels, although the lowest observable effect level (LOEL) varies by species and compound.[11] Definitive links between CAFO-originated hormone concentrations and altered aquatic species are complicated by the presence of other contaminants and environmental conditions; however, hormone concentrations in surface waters affected by CAFOs have been shown to be above some of the reported LOELs.[1,9] Also noteworthy is that whereas the 17β isomers of E2 and TB induce effects at much lower concentrations (<100 times lower) than the 17α isomers or other metabolites in mammalian toxicological studies, similar trends are not observed for aquatic species.[11−15] For example, 17α-E2 was found to be only 8−30 times less potent than 17β-E2 to medaka fish and fathead minnows, 17α- and 17β-TB were found to have similar reproductive effects on fathead minnow,[14,16] and E1 was found to skew sex ratios toward females and induce vitellogenin production in zebrafish at concentrations similar to or lower than those of 17β-E2.[11]

Despite the recognized negative effects of hormones on fish and other aquatic organisms, the fate and transport of hormones in agroecosystems remain poorly understood, with many studies to date being limited to experimental plots under simulated rainfall.[4,17] This study focused on hormone release from subsurface tile-drained agricultural fields at a Midwest U.S. farm where various types of animal wastes including dry manure solids, liquid manure, and animal lagoon effluent are applied to fields. Hormone concentrations were monitored in tile drains and the ditch network receiving tile drainage during storm events, base flow, effluent irrigation, and thawing/snowmelt events. The hormones monitored included 17α- and 17β-E2, E1, estriol (E3), testosterone (TST), androstenedione (AND), 17α- and 17β-TB, and TND. Hormone structures and selected chemical properties are listed in Table SI-1 of the Supporting Information (SI).

MATERIALS AND METHODS

Study Site. This study was conducted in north central Indiana at Purdue University's Animal Science Research and Education Center (ASREC), which is a working farm, an EPA-designated CAFO, and includes approximately 600 ha of tile-drained cropland. Soils at the site are predominantly silty clay loams and silt loams with loess and glacial till as the soil parent materials. Due to the presence of these poorly drained soils, perforated subsurface tile drains ranging in diameter from 10 to 61 cm were installed in the early 1990s approximately 1 m below the soil surface at 8−40 m spacings. Site maps and additional details are provided in the SI. Animal production at ASREC includes beef, dairy, poultry, sheep, swine, and Ossabaw swine units (see SI for details). Beef cattle each received a Revalor-S hormone implant containing 28 mg of 17β-E2 and 140 mg of TBA. Animal wastes are collected and stored on-site. Primary storage includes below-ground pits that are washed into above-ground lagoon systems,[18] above-ground storage units of liquid slurry from liquid/solid separators, and above-ground stacking of bedding/manure wastes. Wastes are land-applied via solids broadcasting (dewatered bedding/manure wastes), pivot irrigation (effluent from on-site lagoons), or subsurface injection (liquid slurry from above-ground storage units). Further details are provided in the SI.

Monitoring stations were installed to measure discharge and collect water samples at four tile drains (stations D1−D4) and three locations (stations S1−S3) in the ditch network at ASREC (SI, Figures SI-1 and SI-2). Each station consisted of a Campbell Scientific CR1000 datalogger, a Campbell Scientific 107 water temperature probe, a flow and/or water level sensor, a Teledyne ISCO automated sampler, and a Campbell Scientific radio and antenna enabling two-way wireless communication. Tile drains monitored by D1 and D2 are 30.5 cm in diameter, and those monitored by D3 and D4 are 61 cm in diameter. The flow rate in each tile was measured with a Marsh-McBirney Flo-Tote 3 and Flo-Station. Water levels in the ditches were monitored with a Campbell Scientific shaft encoder pulley system, and rating curves were developed to calculate flow rates.

Stations were located to capture each major animal waste application practice according to ASREC's manure management plan: (i) beef and dairy effluent (D1 and S1); (ii) beef and dairy effluent and annual applications of dairy solids (D3 and S2); and (iii) poultry and swine effluent (D4 and S3). For fields drained by D2, beef and dairy manure solids had been routinely applied up to 2007, but not during our study period. Although the major waste sources did align with our station plan, additional sources were occasionally applied to some fields. Details regarding all applications are provided in the SI (Tables SI-2−SI-8). After the start of our study, piping between lagoon systems (referred to as an interconnect system) was installed as an additional safety measure to better control lagoon heights. In addition, two valves in this interconnect system were identified to leak, thereby causing unintentional transport from north to south lagoon systems. This led to the movement of some beef wastes to the dairy, swine, and poultry lagoon systems.

Within the ditch network, S1 and S2 monitored Marshall Ditch and S3 monitored Box Ditch (SI, Figure SI-1). S1's drainage area encompassed the tile-drained area monitored by D1. S2 was located downstream of S1 and received drainage from areas monitored by stations D1, D2, D3, and S1. S3's drainage area encompassed the area monitored by station D4. Station drainage area details and total amounts of animal wastes applied are provided in Table SI-2 of the SI. Data were collected at some stations for over 2 years; however, the work presented here is focused on the data collected from January 2009 through March 2010, prior to the commencement of spring animal waste applications.

In addition to the monitoring stations at ASREC, we monitored subsurface tile drainage from a control plot at Purdue's Water Quality Field Station (WQFS), which immediately neighbors the east boundary of ASREC. This control plot (E30) has received only commercial N fertilizer for over 10 years and has never had any animal wastes intentionally applied to the field. We monitored plot E30 as a control plot from August 14, 2009, to May 16, 2010, during our ASREC study. Details are provided in the SI.

Sampling Methodology and Analysis. *Sampling Methods.* Samples were collected in 1 L polyethylene bottles using Teledyne ISCO samplers controlled by dataloggers programmed to trigger samples at time-paced intervals during base flow and at flow-paced intervals over hydrographs. Each time a sample was triggered, a 1 L sample was collected. Samples on the rising limb of hydrographs were collected at preprogrammed flow rate thresholds to appropriately capture the rise. D1 and S1 dataloggers were programmed such that real-time flow data were used to

Table 1. Data Summary Including Maximum Observed Concentrations, Percent of Total Samples Collected That Were Greater than the LOD and LOQ, and Total Number of Samples Collected (n)[a]

hormone (LOD, LOQ) (ng/L)	D1 max (ng/L) % n > LOD, % n > LOQ n	D2 max (ng/L) % n > LOD, % n > LOQ n	D3 max (ng/L) % n > LOD, % n > LOQ n	D4 max (ng/L) % n > LOD, % n > LOQ n	S1 max (ng/L) % n > LOD, % n > LOQ n	S2 max (ng/L) % n > LOD, % n > LOQ n	S3 max (ng/L) % n > LOD, % n > LOQ n
estrogens							
17β-E2	9.5	4.2	16.4	16.3	9.3	20.9	12.1
(0.06, 0.21)	33%, 19%	34%, 11%	39%, 20%	50%, 29%	39%, 23%	43%, 22%	58%, 30%
	n = 589	n = 190	n = 531	n = 552	n = 595	n = 683	n = 372
E1	18.1	1.3	25.6	33.5	23.1	40.0	9.0
(0.05, 0.16)	48%, 19%	25%, 10%	46%, 20%	78%, 41%	62%, 36%	89%, 52%	91%, 55%
	n = 589	n = 190	n = 531	n = 552	n = 595	n = 683	n = 372
17α-E2	51.8	26.7	31.1	13.3	14.1	26.9	6.1
(0.09, 0.29)	17%, 7%	13%, 8.4%	24%, 14%	18%, 11%	14%, 6.7%	29%, 11%	23%, 9.7%
	n = 589	n = 190	n = 531	n = 552	n = 595	n = 683	n = 372
E3	3.5	NA	NA	19.6	7.8	12.4	NA
(0.21, 0.64)	1.4%, 0.7%	1.1%, 0%	1.5%, 0%	2.6%, 1.1%	4.1%, 1.4%	2.5%, 1.6%	2.4%, 0%
	n = 581	n = 187	n = 522	n = 537	n = 590	n = 674	n = 368
total	68.7	27.1	53.5	42.8	23.6	87.0	12.5
	64%, 36%	27%, 23%	69%, 40%	88%, 64%	69%, 43%	91%, 60%	95%, 66%
synthetic androgens							
17β-TB	34.0	13.1	13.6	18.6	53.6	162	3.3
(0.47, 1.6)	4.6%, 1.4%	0.5%, 0.5%	4.7%, 2.0%	3.7%, 1.4%	4.2%, 2.6%	5.5%, 3.9%	2.6%, 0.6%
	n = 589	n = 183	n = 508	n = 518	n = 576	n = 506	n = 345
TND	28.5	NA	12.2	12.1	6.5	6.5	35.3
(1.9, 6.4)	3.5%, 0.7%	15%, 0%	4.0%, 0.3%	5.7%, 1.5%	3.5%, 0.2%	3.7%, 0.3%	13%, 8.5%
	n = 423	n = 142	n = 351	n = 332	n = 402	n = 377	n = 236
17α-TB	8.9	1.4	22.7	18.7	9.7	19.1	11.7
(0.22, 0.74)	6.8%, 5.6%	1.1%, 1.1%	1.4%, 1.0%	5.7%, 4.9%	3.3%, 2.6%	3.7%, 2.8%	1.4%,1.4%
	n = 589	n = 183	n = 508	n = 518	n = 576	n = 506	n = 345
total	36.8	13.4	30.1	32.7	54.3	168	35.6
	13%, 6.8%	13%, 1.6%	7.7%, 3.0%	10%, 6.7%	7.6%, 3.8%	9.0%, 4.4%	10%, 7.5%
natural androgens							
TST	12.7	2.4	3.7	16.1	50.5	15.4	11.7
(0.17, 0.58)	11%, 5.4%	31%, 10%	16%, 7%	15%, 7.9%	26%, 14%	26%, 15%	21%, 10%
	n = 589	n = 183	n = 508	n = 518	n = 576	n = 545	n = 345

Table 1. Continued

hormone (LOD, LOQ) (ng/L)	D1 max (ng/L) % n > LOD, % n > LOQ n	D2 max (ng/L) % n > LOD, % n > LOQ n	D3 max (ng/L) % n > LOD, % n > LOQ n	D4 max (ng/L) % n > LOD, % n > LOQ n	S1 max (ng/L) % n > LOD, % n > LOQ n	S2 max (ng/L) % n > LOD, % n > LOQ n	S3 max (ng/L) % n > LOD, % n > LOQ n
AND	1.6	2.1	8.2	12.5	16.6	9.4	5.0
(0.12, 0.41)	14%, 4.8%	21%, 3.8%	19%, 9%	21%, 9.1%	17%, 3.6%	37%, 11%	43%, 19%
	n = 589	n = 183	n = 508	n = 518	n = 576	n = 545	n = 345
total	14.2	2.4	8.2	22.8	51.7	16.2	11.9
	22%, 9.5%	31%, 10% = 183	30%, 14%	39%, 16%	35%, 15%	50%, 22%	52%, 28%

[a] The summary is for samples collected from January 2009 through March 2010 (prior to the commencement of spring 2010 effluent irrigation). Note that due to equipment errors, data at D4 and S3 are reported only through December 2009. NA, maximum concentration not applicable; all concentrations were below the LOQ.

predict the hydrograph recession and the collection times at flow-paced intervals for the remaining samples to ensure that not all bottles were filled before the end of the recession.[19] A variation of this methodology was employed at the remaining stations with preprogrammed flow-paced intervals determined by the value of the peak flow rate such that sufficient samples would be collected during the recession for both small and large hydrographs.

Sample Preparation. Sample preparation is detailed in the SI. Briefly, water samples (1 L) were refrigerated immediately upon receipt in the laboratory for typically less than 36 h but no longer than 72 h prior to solid-phase extraction. Samples were weighed, filtered, amended with deuterated standards (6.25 ng of 17β-E2-16,16,17-d_3 and 5 ng of TST-16,16,17-d_3 dissolved in 0.5 mL of methanol), and preconcentrated by solid-phase extraction immediately or stored at 4 °C in the dark for typically less than 36 h but no longer than 72 h prior to further processing. Loaded cartridges were stored at −20 °C for up to 4 months prior to washing and eluting analytes with methanol. The eluant was evaporated to dryness, and residues were reconstituted in methanol (0.5 mL). Samples were analyzed using high-performance reverse-phase liquid chromatography tandem electrospray ionization mass spectrometry (HPLC-ESI-MS/MS).

HPLC/MS/MS Analysis. LC/MS/MS analysis was performed using a Shimadzu HPLC system coupled to a Sciex API-3000 triple-quadrupole operated in multiple reaction monitoring mode. Column and mobile phase gradient details for estrogens and androgens are summarized in Tables SI-10 and SI-11 of the SI, respectively. Retention times, precursor and product ions monitored, and the method limits of detection (LOD) and quantitation (LOQ) for aqueous samples are summarized in Table SI-12 of the SI. Method LOD and LOQ values for each hormone are also provided in Table 1 for easy reference. Other analyses performed and detailed in the SI include sample matrix effects on HPLC/ESI-MS/MS response to hormones, extraction recovery of hormones, hormone sorption to ISCO polyethylene collection bottles, and hormone stability in field samples.

RESULTS AND DISCUSSION

Hormone Recovery, Matrix Effects, and Stability. Hormone concentrations were corrected for recoveries and matrix effects using deuterated internal standards added prior to extraction and assuming similar extraction efficiencies based on similar hydrophobicities (SI, Table SI-1) and that signal suppression for estrogens and androgens could be reasonably approximated by 17β-E2-16,16,17-d_3 and TST-16,16,17-d_3, respectively. Internal standard recoveries with matrix corrections were in the range expected for large field studies with >78% of the recoveries being between 50 and 150% with an average recovery in this ranges of 91.1 ± 18.3% for 17β-E2-16,16,17-d_3 and 73 ± 19.6% for TST-16,16,17-d_3 (SI, Table SI-14). Any samples with an internal standard recovery outside the 50−150% range were included in the data analysis, but not modified by internal standard recoveries. Hormone-specific recoveries (SI, Table SI-13) and matrix effects were assessed as detailed in the SI (Figures SI-3 and SI-4). Potential errors in reported concentrations using the internal standards for recovery and matrix effects are generally within 20% (SI, Table SI-13).

Hormones are subject to sorption and microbial degradation from the time of ISCO collection to the loading of the aqueous samples onto the solid-phase cartridges. Sorption to polyethylene

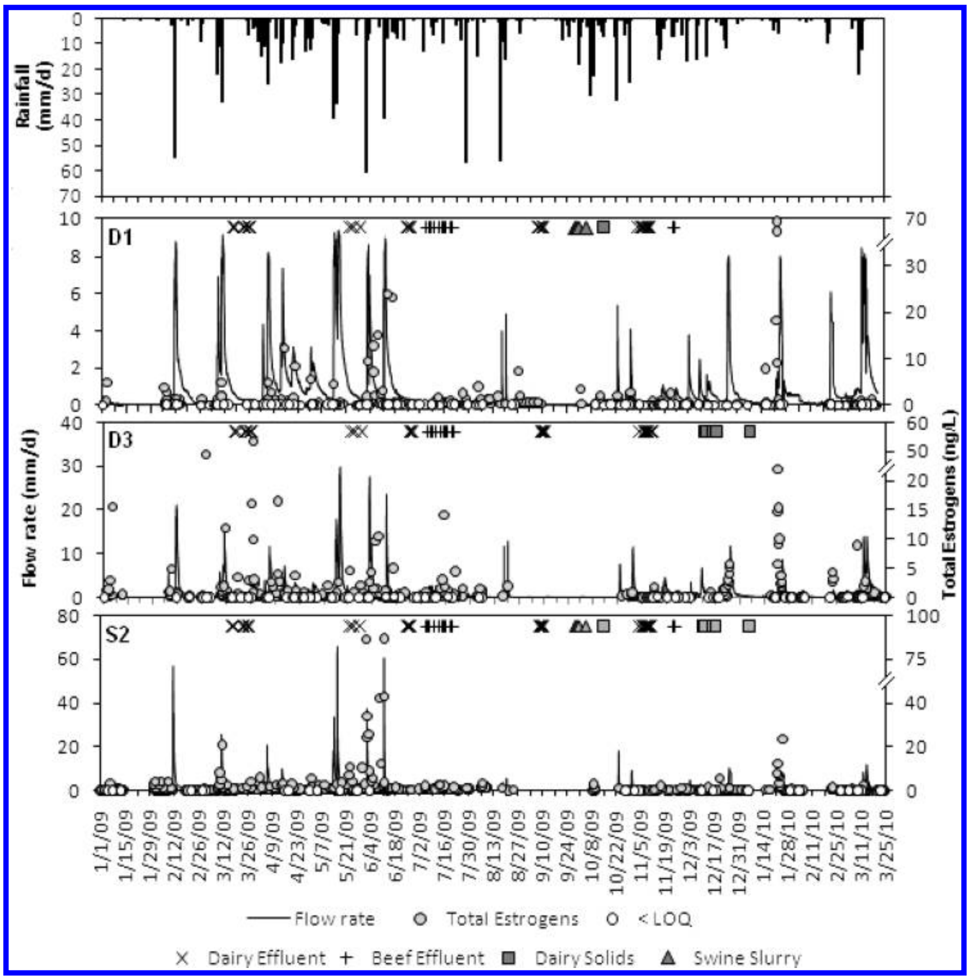

Figure 1. Hyetograph, hydrographs, and total estrogen chemographs (E1 + E2 + E3) for the study period at D1, D3, and S2. Animal waste applications are shown across the top of each panel. For graphical clarity, several high total estrogen concentrations are shown using a broken-axis notation.

bottles was assessed at 4 °C over a 72 h period (detailed in the SI). Concentrations were found to vary <5% at 0, 24, 48, and 72 h with no statistical differences at the 95% confidence level. The potential loss of hormones during sample processing was evaluated by monitoring hormone-amended S2 ditch water incubated under representative conditions, which included unfiltered and filtered stream water at 4 °C and ~23 °C. Data from stream water amended with hormones in the laboratory suggest that prior to filtering, there is a substantial degradation potential for some of the hormones within the first 24 h (SI, Figure SI-5 and SI-6), especially the natural androgens, of which up to 50% was gone within the first 24 h at 23 °C. If degradation rates estimated from the laboratory-fortified ditch water were directly applicable to field samples, then at near-steady-state conditions in the ditch network, concentrations for samples collected at later times would be expected to be higher than those from earlier collection times prior to sample pickup. However, this was not the case even for samples collected over a ~72 h period in the summer months (air temperatures of 15−30 °C). We suspect that the aerobic microbial degradation rates measured in the laboratory experiments were greatly elevated relative to the field due to aeration of the ditch water during homogenization immediately prior to hormone addition and potentially the concomitant addition of methanol (hormone carrier), which may serve as a readily available microbial food source.[20,21] Even with the expectation that degradation in our actual site samples is considerably slower than observed in well-mixed laboratory-amended ditch water, the hormone concentrations reported from subsurface tile drain and ditch network samples are likely still underestimated.

Hormone Discharge Dynamics. After land application, biogeochemical and hydrologic processes control the subsequent transport of hormones. Seasonal differences in rainfall intensity and amount, temperature, and waste management strategies confound the ability to discern between environmental and anthropogenic influences on hormone dynamics. In addition, deviations from the anticipated management plan at our study site and the intentional and unintentional routing of wastes between animal-specific lagoon systems prevent an explicit delineation of hormone release between waste types in this study. Furthermore, data interpretation of specific hormones may be biased as a result of degradation during sample collection/processing. To minimize under-representation of the hormone concentrations and associated biases, hormone levels were primarily assessed in terms of total estrogens, synthetic androgens, and natural androgens. Given the greater stability of E1 (metabolite of E2 isomers) and TND (metabolite of TB isomers), errors in total estrogens (17α-E2, 17β-E2, E1, and E3) and total synthetic androgens (17α-TB, 17β-TB, and TND), respectively, will be much smaller than the error associated with

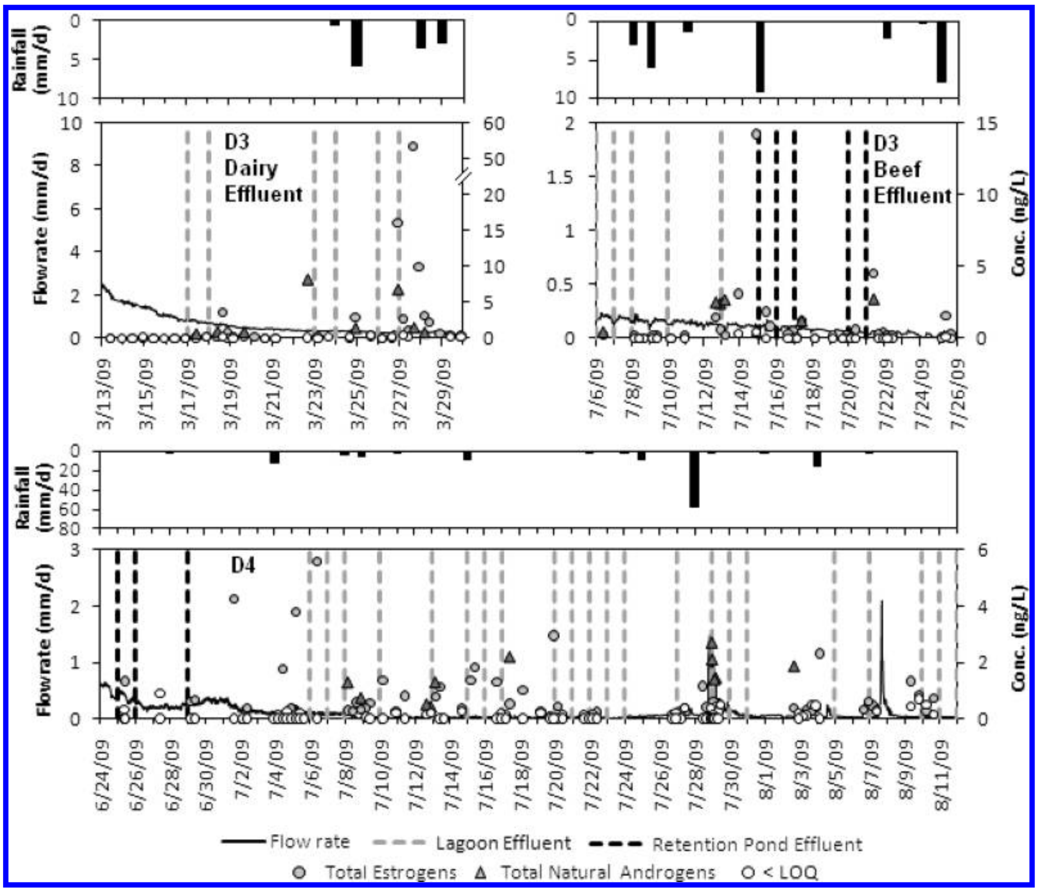

Figure 2. Hyetograph, hydrographs, and total estrogen and total natural androgen chemographs at D3 and D4. Effluent irrigation events (65.5 m^3/ha) are shown as dashed vertical lines (gray, lagoon effluent; black, retention pond effluent).

each individual hormone. Concentrations for the natural androgens (TST and AND) are likely the most underestimated because both TST and its metabolite AND degraded the most rapidly in the laboratory assessment. Using this approach, data analysis focused on trends observed during storm events, release during snowmelt events, and the influence of effluent irrigation on hormone concentrations in subsurface tile drainage. Although concentrations are likely underestimated in this study, the general trends are expected to remain the same. Given the large data set, various monitoring stations, and range of waste application types, the resulting summarization of general hormone discharge dynamics is likely to be representative of many tile-drained fields receiving animal waste applications.

Hormone Concentration Summary. The most to least frequently detected estrogens at each sampling location were E1, 17β-E2, 17α-E2, and E3, with E3 detected in <5% of samples (Table 1). Additionally, natural androgens (TST and AND) were detected more frequently than synthetic androgens (TB and TND), which were detected in <15% of the samples. Overall, hormones were detected in at least 64% of samples collected at each station that received animal waste applications during the study period. Ditch water total estrogen (E1 + E2 + E3) concentrations were highest in the spring and summer, with the maximum (87 ng/L) observed on June 1, 2009 at S2 during a 6 cm rainfall event that occurred 3 days after fields were irrigated with dairy effluent. On average, androgen concentrations were highest during the fall and winter (SI, Figures SI-7 and SI-8). The highest concentration of synthetic androgens (168 ng/L) was observed in relation to a snowmelt. However, the highest total natural androgen concentration (52 ng/L) was observed on June 25, 2009, during dairy effluent irrigation. The May−June time frame coincides with early life stage development period, a sensitive time for gonadal development and sexual differentiation, for many aquatic species.[9]

Hormone concentrations measured in the samples collected from August 14, 2009 to May 16, 2010 at the WQFS control plots are summarized in Table SI-16 of the SI. Almost all estrogen and androgen concentrations were below the LOQ with the exceptions of 17β-E2 and E1. 17β-E2 was observed in two samples with a maximum concentration of 3.13 ng/L in January 2010. E1 was observed in five samples with a maximum value of 0.38 ng/L.

Hormone Discharge during Storm Hydrographs. The influence of precipitation events on the tile drain and ditch network hydrographs is dependent on storm intensity and duration, evapotranspiration, and antecedent soil moisture conditions. During the summer months, increased evapotranspiration due to rapid crop growth and warm temperatures led to lower antecedent moisture conditions and lower tile drain and ditch flow rates relative to the winter and spring. Flow and total estrogen data collected during the study period are shown in Figure 1 for D1, D3, and S2 along with timing of animal waste applications and rainfall. Additional figures for the remaining monitoring stations and the androgens (natural and synthetic) data are provided in the SI (Figures SI-7−SI-12). Note that values in all of the hyetographs represent total daily rainfall (not intensity),

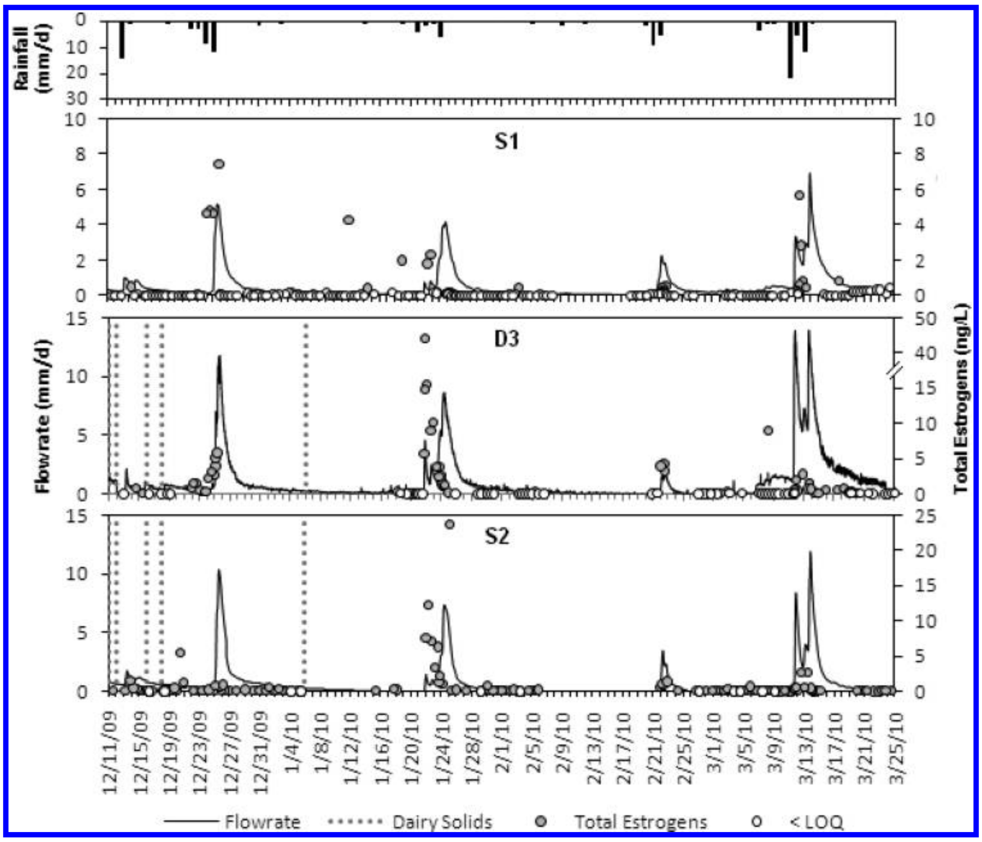

Figure 3. Hyetograph, hydrographs, and total estrogens (E1 + E2 + E3) chemographs for S1, D3, and S2 during the winter and early spring prior to the commencement of spring effluent irrigation. The timing of dairy solids applications (32.5 m^3/ha) at fields monitored by D3 and S2 are shown as dotted vertical lines. S1 received dairy and beef effluent irrigation in late November 2009 (see Table SI-6 of the Supporting Information) and is shown for comparison. Due to a sampler error, samples were missed on the recession limb of the storm hydrograph on December 23−27, 2009. Snow records indicate that snowmelt coincided with rainfall on December 22−24, 2009 (~5 cm), and February 19−20, 2010 (~8 cm). Snowmelt (~20 cm) occurred without rainfall on January 11−16, 2010.

and hormone concentrations below the LOD are plotted as 0 ng/L in all of the chemographs.

During storm hydrographs, hormone concentrations generally increased as exemplified at D1, D3, and S2 in Figure 1 for total estrogens for the study period (January 2009−March 2010). Peak concentrations were often highest during the first storm event following an animal waste application with lower concentrations observed in subsequent events before additional applications (e.g., April 2009 for D1 in Figure 1). Hormone chemographs also generally paralleled hydrographs with hormone concentrations increasing along the rising hydrograph limb, peaking near the hydrograph peak, and decreasing along the recession limb in tile drains and ditches (Figure 1 and further exemplified for D1 and D4 in Figure SI-10 of the SI). These chemograph−hydrograph similarities were the most pronounced during the first storm hydrograph following an application regardless of the magnitude of the peak storm hydrograph flow rate. The steep rising limb of tile drain hydrographs is due primarily to macropore flow, which is known to transport land-applied chemicals to receiving ditches, especially in the first two rain events after application.[22]

Transport of hormones sorbed to soils or associated with manure solids (see Table SI-1 of the SI) are also highly subject to surface runoff during high-intensity rain events. Although surface runoff was not measured directly, it was inferred to occur when flow in the smaller tile drains (e.g., D1) reached full capacity and the area-normalized flow rates were substantially higher in the ditches than in the larger tile drains (e.g., D3). Intense rains occurred several times in May and June 2009, leading to full-capacity tile flow in D1 and surface runoff to the ditch network (e.g., D1 and S2 in Figure 1 and detailed in Figure SI-11 of the SI). During the first two storm events in June after dairy effluent irrigations, total estrogens (Figure 1 and Figure SI-11 of the SI), natural androgens (SI, Figure SI-7), and synthetic androgens (SI, Figure SI-8) in ditch water increased to levels above those observed in the tile drains with concentrations highest at S2 (downstream of S1). Surface runoff is typically high in suspended solids, to which hormones may be sorbed. Hormone concentrations at D2, which drains an area that had not received manure applications since 2007, also increased during these events (SI, Figure SI-12).

Rapid Transport following Effluent Irrigation. Effluent irrigation is typically used during late spring and summer while crops are growing and evapotranspiration rates are high; however, to minimize the potential of lagoon overflow during periods of snowmelt and heavy spring rainfall, effluent was also frequently applied in March and November (see Tables SI-3−SI-8 of the SI). In general, hormone concentrations following effluent irrigation increased during rainfall events as exemplified in Figures 1 and 2. Additionally, hormone concentrations occasionally were observed to increase during and shortly after effluent irrigation events that were not associated with rainfall. For example, hormone concentrations

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increased on March 18 and 27−28, 2009 at D3 following dairy effluent irrigation, July 12−13, 2009 at D3 following beef effluent irrigation, and during several poultry effluent irrigation events during July and August 2009 at D4 (July 12−13, 17, and 27; August 6 and 10) (Figure 2). Elevated concentrations, albeit low nanograms per liter, were also observed at D1 during July 2009 irrigations (Figure 1). These trends were more pronounced when effluent irrigations occurred shortly after rainfall, which increased antecedent soil moisture. Higher antecedent soil moisture conditions have been correlated to enhanced macropore flow of chemicals,[22,23] although not consistently.[24] Effluent irrigation also influences soil moisture conditions, as each irrigation (65.5 m^3/ha) was the equivalent (in terms of moisture) to ~6.6 mm of rainfall. In some cases, hormone concentrations in tile drainage were higher during effluent irrigation than during rainfall events (e.g., March 26−28 at D3; July 12−13 at D3; July 12−13 and 17 at D4). Hormone concentrations in tile drains immediately following effluent irrigation appear to be indicative of preferential flow through an established macropore network. The latter is consistent with subsurface tile drainage studies in which tracers in irrigation water reached the tile drain within 1 h after irrigation regardless of their sorption characteristics.[22]

Although no direct measurements of preferential flow were made at the study site (e.g., tracer studies), preferential flow is known to occur at similar subsurface tile-drained fields and has been observed within tracer studies at experimental tile-drained plots at the Purdue WQFS immediately adjacent to ASREC.[25] These observations of rapid solute transport to subsurface tile drains are consistent with observations at several other field studies.[26−29] Notably, Lapen et al.[27] observed "application-induced discharge" (as opposed to "precipitation-induced discharge") of pharmaceuticals and personal care products to tile drains following land application of biosolids with concentrations increasing within minutes after application. They attributed this rapid transport to flow through networks in the soil that directly connect to the tile drains (i.e., preferential flow pathways). Transport through such networks reduces the reactive time with soil particles, potentially reducing sorption and degradation[30] and increasing the potential importance of preferential flow to water quality implications with regard to hormones.

Hormone Preservation and Discharge during Cold Months. According to best management practices, solid manure applications should occur when soil temperatures drop below 10 °C to minimize the potential for nutrient loss;[31] however, colder temperatures also can preserve manure-borne hormones. When temperatures rose in early February 2009 (>13 °C) and caused a snowmelt (~5 cm of snow was on the ground at this time), total estrogen concentrations increased to 12 ng/L at D3 (Figure 1), for which the last waste application had been dairy solids in September 2008. Estrogen concentrations also increased during a large rain event (total rainfall of 6.5 cm over a period of 4 days) in early March 2009 at both D3 and S2 prior to the commencement of spring effluent irrigation (Figure 1). Total synthetic hormones also increased at D3 and S2 during this event, with S2 reaching a maximum value of ~170 ng/L (SI, Figure SI-8). Fields drained by D1 and S1 did not receive solid applications but were irrigated multiple times with dairy and beef effluent in fall 2008 (SI, Tables SI-3 and SI-6). Additionally, estrogen concentrations increased at D1 during the February snowmelt and early March rain event, although concentrations were higher at D3 and S2 (Figure 1). Total synthetic hormone concentrations also increased at D1, D3, and S1 during the February event (SI, Figure SI-8). These observations suggest that hormones are preserved in the field during the winter months and that fall applications of solids lead to greater winter and early spring export of hormones than fall effluent irrigation.

Similar trends were observed at D3 and S2 in winter 2009 and early spring 2010 (Figure 3). Fields monitored by D3 and S2 received several applications of dairy solids later in the year in 2009 than in 2008, with one application occurring in early January 2010 when ~5 cm of snow was on the ground (SI, Tables SI-4 and SI-7). Fields monitored by D1 and S1 received one application of dairy solids in early October 2009 and multiple applications of dairy and beef effluent (SI, Tables SI-3 and SI-6). Total estrogen concentrations increased during each storm event following these applications (Figure 3) through March prior to the commencement of spring effluent irrigation. Hormone concentrations increased to higher values at D3 and S2 than at S1 during the rain event on January 22−28, 2010, likely due to the recent dairy solids applications. The apparent preservation of hormones exemplified three times at the site (early and late 2009 and early 2010) suggests that such winter and early spring dynamics play a significant role in hormone export and can be expected at other subsurface tile-drained sites.

Implications and Study Limitations. Subsurface tile drains are well-known to change the pore structure within soil profiles, dramatically altering the natural hydrology and expediting the transport of water and solutes through the soil profile, into the tile drains, and ultimately into nearby surface water bodies.[22] However, the role these systems play in hormone discharge following land application of animal wastes is not well-known. Rapid increases in hormone concentrations observed in tile drains following effluent irrigation suggest aqueous and particulate-borne hormones are rapidly transported to subsurface tile drains through an established macropore network consistent with tracer irrigation studies.[22] During storm events, the rise and fall of hormone concentrations in tile drainage generally followed hydrograph trends. When smaller tile drains flowed full and area-normalized ditch flow rates increased significantly compared to flow in the larger tile drains, elevated hormone concentrations in the ditch network relative to tile drainage suggested hormone transport via surface runoff. Peak hormone concentrations in the ditches occurred in June shortly after effluent irrigation, coinciding with a sensitive early life stage development period for many aquatic species. Cold temperatures during the winter months appeared to preserve hormones from late fall animal waste applications and resulted in increased hormone export during storm events via tile drainage to the ditch network in the early spring. This increase in hormone concentrations during storm events continued for as long as 4 months after fall animal waste applications. Winter rain events and snowmelt increased exported hormone concentrations three times during the 15 month monitoring period (early and late 2009 and early 2010), suggesting that hormone export through such winter and early spring dynamics may be expected at similarly managed subsurface tile-drained sites.

The ASREC site presented a unique opportunity to evaluate the discharge of hormones following various animal waste applications occurring at similar field study sites, with each animal waste type applied multiple times during the study period. Although the study did add to our understanding of the potential contribution of hormones from animal-derived effluent and solid wastes applied to subsurface tile-drained fields, the management complexity of the site, including multiple types of wastes applied to a single drainage area, limited explicit interpretation of the data collected. Sufficient characterization of the waste being applied was also limited due to the challenge of obtaining waste samples in a regular and timely manner given the application frequency and more pressing responsibilities of farm personnel. In addition, identifying some level of sample preservation that did not interfere with hormone analysis would have helped to minimize underestimation of the discharged hormone levels. Finally, real-time monitoring of soil moisture and several key surface runoff collection points would have improved the utilization of the data set toward recommending improved animal waste management strategies.

■ ASSOCIATED CONTENT

Supporting Information. Study site details and figures, additional information regarding sample analysis, and additional figures depicting hormone chemograph behavior. This material is available free of charge via the Internet at http://pubs.acs.org.

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Attachment 20:

University of Missouri:
Assessing the Risk of Groundwater Contamination
from Animal Manure Management Facilities

University of Missouri Extension

WQ657, New October 1995

Assessing the Risk of Groundwater Contamination from Animal Manure Management Facilities

Farm•A•Syst: Farmstead Assessment System Worksheet #7

Included when you order this worksheet: MU publication WQ681, Reducing the Risk of Groundwater Contamination by Improving Animal Manure Management, the fact sheet that corresponds with this worksheet.

Livestock lots, such as barnyards, holding areas and feedlots, are areas of concentrated livestock wastes. Total confinement facilities also are areas of concentrated livestock waste. These areas can be a source of nitrate and bacteria contamination of groundwater. This is especially true if there is no system to

- Divert clean water flow from the livestock lot
- Collect polluted runoff from the lot for diversion to an area where its effect on surface water or groundwater is minimal

The potential for livestock lots to affect groundwater is greatest if the lot is located over coarse-textured permeable soils, if the water table is at or near the surface, if bedrock is within a few feet of the surface or if polluted runoff is discharged to permeable soils and bedrock.

Drinking-water nitrate levels that are above federal and state drinking water standards of 10 milligrams per liter (mg per liter; equivalent to parts per million [ppm] for water measure) nitrate-nitrogen can pose health problems for infants under 6 months of age, including the condition known as methemoglobinemia (blue baby syndrome). Nitrate also can affect adults, but the evidence is much less certain.

Young livestock also are susceptible to health problems from high nitrate-nitrogen levels. Levels of 20 milligrams per liter to 40 milligrams per liter in the water supply may prove harmful, especially in combination with high levels (1,000 ppm) of nitrate-nitrogen from feed sources.

Fecal bacteria in livestock waste can contaminate groundwater if waste seeps into nearby wells, causing such infectious diseases as dysentery, typhoid and hepatitis. Organic materials, which may lend an undesirable taste and odor to drinking water, are not known to be dangerous to health, but their presence does suggest that other contaminants are flowing directly into groundwater.

Facilities for storing liquid manure on the farmstead sometimes leak or burst, releasing large volumes of pollutants. Manure in earthen pits can form a semi-impervious seal of organic matter that does limit leaching potential, but seasonal filling and emptying can cause the seal to break down. Short-term solid-manure storage and abandoned storage areas also can be sources of groundwater contamination by nitrates. Manure can contribute nutrients and disease-causing organisms to both surface water and groundwater.

Silage liquid is highly acidic and can be corrosive to concrete and steel. If it enters a stream, its high organic content feeds bacteria that rob the water of oxygen. Groundwater contaminated with silage juices has a disagreeable odor and shows increased levels of acidity, ammonia, nitrates and iron.

Along with the pollutants found in silage leachate, an even greater potential threat is the low pH created by the presence of acids in silage leachate that can cause the release of naturally occurring metals in the soil and aquifer, increasing their concentrations in groundwater.

Milking-center wastewater is contaminated with organic matter, nutrients, chemicals and microorganisms. Poorly designed or mismanaged waste-disposal systems can contaminate water with ammonia, nitrate, phosphorus, detergents and disease-causing organisms. If not managed properly, these contaminants can be carried directly to a well or cause groundwater or surface-water contamination. Surface water and groundwater also can be affected by manure, milk solids, ammonia, phosphorus and detergents.

The goal of Farm•A•Syst is to help you protect the groundwater that supplies your drinking water

How will this worksheet help me protect my drinking water?

It will take you, step by step, through your animal-waste management facilities.

- It will rank your activities according to how they might affect the groundwater that provides your drinking-water supplies.
- It will provide you with easy-to-understand rankings that will help you analyze the "risk level" of each component of your animal-waste facilities.
- It will help you determine which of your practices are reasonably safe and effective and which practices might require modification to better protect your drinking water.

How do I complete the worksheet?

Follow the directions at the top of the chart in Table 1. It should take you about an hour to complete this worksheet and figure out your ranking. Complete the questions that apply to your farmstead.

> **Note**
> If your milking-center wastes receive primary treatment through an aerobic lagoon or aerated septic tank, it may be discharged into your livestock-waste facility.

Table 1
Animal manure management facilities: Assessing drinking-water contamination risk.

1. Use a pencil. You may want to make changes.
2. For each category listed on the left that is appropriate to your farmstead, read across to the right and circle the statement that **best** describes conditions on your farmstead. (Skip and leave blank any categories that don't apply to your farmstead.)
3. Then look above the description you circled to find your "rank number" (4, 3, 2 or 1) and enter that number in the blank under "your rank."
4. Directions on overall scoring appear at the end of the worksheet.
5. Allow about 15 minutes to 30 minutes to complete the worksheet and figure out your risk ranking for well-management practices.

Livestock lots					
	Low risk, rank 4	**Low to moderate risk, (rank 3**	**Moderate to high risk, rank 2**	**High risk, rank 1**	**Your rank**
Location					
Distance from drinking-water well	More than 300 feet.	200 to 300 feet.	75 to 200 feet.	Less than 75 feet [1,2]	

Site characteristics					
Soil depth and permeability	Well-drained medium- or fine-textured soils (loam, silt loam, clay loams, clays). With low permeability (silt and clay). More than 40 inches deep with low permeability (silt and clay).	Well-drained or moderately well-drained medium- or fine-textured soils (loam, silt loam, clay loam, clay). 30 inches to 40 inches deep with moderate permeability (loamy).	Moderately well-drained coarse-textured soils (sand, sandy loam). Shallow (20 to 30 inches) and/or high permeability (sandy).	Excessively well-drained coarse-textured soils (sand, sandy loam) to gravel, and/or somewhat poorly drained soil to poorly drained soils. Very shallow (less than 20 inches) and/or very high permeability (coarse sand).	
Design and management					
Surface-water diversion	All upslope and roof water diverted.	Most upslope surface and roof water diverted.	No surface water diverted. Some roof water collected and redirected.	All water (surface and roof water) runs through lot.	
Lot-runoff control system	No lot runoff (either barn or roofed area).	All runoff collected from curbed lot. Solids separated. Water directed onto properly sized filter strip.	Most of lot runoff collected. Some solids removed. No filter strip.[1]	Lot runoff uncontrolled.[1]	
Lot cleaning and scraping practice	No lot. Confined to barn or roofed lot.	Daily.	Once a week.	Once a month.	
Concentration of Animals on Lot (square feet per animal, sf/a[3])					
Dairy cows		75 sf/a or more more on fenced, curbed concrete pad and/or 400 sf/a on graded earthen surface. More than 1,800 sf/a in exercise area.	50 sf/a or more more on concrete and/or 200 sf/a to 300 sf/a on earthen surface. More than 1,200 sf/a in exercise area.	Some concrete (less than 50 sf/a) and earth (less than 100 sf/a).	
Dairy replacements	No lot. Confined to barn or roofed lot.	More than 40 sf/a on fenced, curbed concrete pad and/or 150 sf/a to 200 sf/a on earthen lot.	More than 20 sf/z on concrete and/or more than 75 sf/a on earthen surface.	Less than 75 sf/a on earthen surface.	
Beef feeders	No lot. Confined to barn with slotted floor.	Barn and/or paved lot more than 50 sf/a. Earthen lot with mound more than 300 sf/a, or without mound more than 500 sf/a.	No shelter and paved lot 40 sf/a to 50 sf/a. Earthen with mound more than 150 sf/a or earthen without mound less than 250 sf/a.	Paved less than 30 sf/a, or earthen less than 150 sf/a.	
Beef cows/heifers	Barn or roofed lot.	Barn with paved paved lot more than 60 sf/a. Earthen with mound more than	Paved lot more than 30 sf/a. Earthen with mound more than	Earthen without mound less than 200 sf/a.	

		400 sf/a. Earthen without mound more than 600 sf/a.	200 sf/a. Earthen without mound more than 300 sf/a.		
Hogs/sows	No yard. Confined to barn.	Shed and paved lot more than 30 sf/a.	Shed and earthen lot less than 15 sf/a.	Shed and earthen lot less than 10 sf/a.	
Pigs: growing/finishing	No yard. Confined to barn.	Shed and paved lot more than 15 sf/a.	Shed and earthen lot more than 15 sf/a.	Shed and earthen lot less than 10 sf/a.	
[1]Besides representing a higher-risk choice, this practice also violates Missouri law. [2]Access of dairy animals to stored manure is in violation of Missouri State Board Regulations. [3]Animal concentrations derived from Midwest Plan Service publications and other sources.					
Animal-waste storage					
Long-term storage (180 days or more)					
Steel, glass-lined (liquid-tight design, above ground)	Designed and installed according to accepted engineering standards and specification s. Properly maintained.	Designed and installed according to accepted engineering standards and specifications. Not maintained.	Leaking tank on medium-textured soils (silt loam, loam).	Leaking tank on coarse-textured soils (sands, sandy loam).	
Or					
Concrete stave (liquid-tight design)	Designed and installed according to accepted engineering standards and specifications. Properly maintained.	Designed and installed according to accepted engineering standards and specifications. Not maintained.	Concrete cracked, medium-textured soils (silt loam, loam).	Concrete cracked, coarse-textured soils (sands, sandy loam).	
Or					
Poured concrete (liquid-tight design)	Designed and installed according to accepted engineering standards and specifications. Properly maintained.	Designed and installed according to accepted engineering standards and specifications. Not maintained.	Concrete cracked, medium-textured soils (silt loam, loam).	Concrete cracked, coarse-textured soils (sand, sandy loam).	
Or					
Earthen waste storage pit (below ground) or Anaerobic Lagoon	Designed and installed according to accepted engineering standards and specification s. Properly maintained.	Designed and installed according to accepted engineering standards and specifications in areas where clay was brought in for a compacted liner or	Not designed to engineering standards. Constructed in medium-or fine-textured dense material (silt loam, loam, clay loam, silty clay).	Not designed to engineering standards. Constructed in coarse-textured material (sand, sandy loam).	

		an artificial liner was used. Properly maintained.			
Short-term storage (usually 60 days to 90 days; in some cases, up to 180 days)					
Stacked in field (on soil base)			Stacked on high ground. Medium- or fine-textured soil (silt loam, loam, clay loam, silty clay).[1]	Stacked on high ground. Coarse-textured soil (sand, sandy loam).[1]	
Stacked in lot[2]	Covered concrete lot with curbs, gutters and settling basin. Runoff to approved structure. Effluent applied to soil-plant filter.	Concrete lot with curbs, gutters and approved storage facilities. Grass filter strips installed and maintained.	Earthen lot with medium- or fine-textured soil (silt loam, loam, clay loam, silty clay). Water table deeper than 20 feet.	Earthen lot with coarse-textured soils (sand, sandy loam). Fractured bedrock or water table shallower than 20 feet.	
Water-tight structure designed to accepted engineering standards andspecifications	Designed and installed according to engineering standards. All liquids maintained.	Designed and installed according to engineering standards on medium- and fine-textured soil (silt loam, loam, clay loam, silty clay). Water table deeper than 20 feet.	Designed and installed according to engineering standards on coarse-textured soils (sand, sandy loam). Water table or fractured bedrock shallower than 20 feet.	Designed and installed according to engineering standards. Not properly maintained. Water treatment and diversion and terrace structures allowed to deteriorate.	
Stacked in open housing	Building has concrete floor, protected from surface-water runoff. Adequate bedding provided.	Building has earthen or concrete floor on medium- or fine-textured soil (silt loam, loam, clay loam, silty clay), protected from surface-water runoff. Water table deeper than 20 feet.	Building has earthen or concrete floor on medium- or fine-textured soil (silt loam, loam, clay loams, silty clay), subject to surface water runoff. Water table or fractured bedrock shallower than 20 feet.	Building has earthen floor on coarse-textured soil (sand, sandy loam), subject to surface-water runoff. Water table or fractured bedrock shallower than 20 feet.	
Location of livestock-waste storage in relation to drinking-water well	Manure stack or earthen waste-storage pit more than 300 feet down-slope from well. Manure storage structure (liquid-tight) more than 100 feet down-slope from well.	Manure stack or earthen waste-storage pit more than 300 feet up-slope from well. Manure storage structure (liquid-tight) more than 100 feet up-slope from well.	Manure stack or earthen waste-storage pit less than 300 feet down -slope from well. Manure storage structure (liquid-tight) less than 100 feet down-slope from well.[1,2]	Manure stack or earthen waste-storage pit less than 300 feet up-slope from well. Manure storage structure (liquid-tight) less than 100 feet up-slope from well.[1,2]	
[1]Besides representing a higher-risk choice, this practice also violates Missouri law. [2]Access of dairy animals to stored manure is in violation of Missouri State Board Regulations.					
Land application of animal waste					

Animal-waste application					
Soil testing of waste-application site	Yearly.	Every two years.	Every three years.	Less frequent than every three years.	
Application rate	Applied at rate equal to or less than plant needs based on soil test and waste analysis.	Nitrogen application rates 100 pounds or less without soil test.	Nitrogen application rates exceed 100 pounds without soil test. Rate may exceed plant needs.	Applied at rate greater than plant needs. Annual application more than 200 pounds available nitrogen.	
Location of waste-application areas	All application areas more than 300 feet from surface water and groundwater sources.	Most application areas more than 300 feet from surface water and groundwater sources.	Several application areas are less than 300 feet from surface water or groundwater sources.	Most application areas within 200 feet of surface water or groundwater sources.	
Application timing and site conditions	Incorporated into soil, applied to no-till field or applied at site with heavy vegetation. Never applied to frozen or saturated soil.	Incorporated into soil, applied to no-till field or applied at site with heavy vegetation. Try to avoid application on frozen or saturated soil.	Application based on when can get around to it. May not coincide with cropping season.	Applied to frozen, saturated or snow-covered soil. Applied to tilled soil with no incorporation and little vegetation.	
Silage storage					
Silage moisture content[2]	Below 65 percent.	Between 65 percent and 75 percent.	Between 71 percent and 85 percent.	More than 85 percent.	
Silage storage location	At least 100 feet downslope from well. Runoff water drains away from storage to field or pasture.	At least 75 feet downslope from well. Runoff water drains to field or pasture.	Within 75 feet up-slope from well. Water pools or stands near storage.	Within 50 feet of well (silos, glass-lined feed storage). Within 250 feet (earthen trench).[1,3] Water pools on soil surface.	
Silage storage floor or surface condition	Concrete or asphalt surface. No cracks.	Concrete or asphalt surface has some cracks.	Surface has some permeable soils (silt loam) and has some cracks.		
Silage storage cover condition	Cover tight-fitting. No leaks.	Cover tight-fitting. Minor leaks repaired			
Silage storage lining	New or relined in last 5 years.	Relined 6 to 25 years ago.			
Leachate collection system	Designed system in place and maintained.	Designed system in place but not maintained.			

[1]Besides representing a higher-risk choice, this practice also violates Missouri law.

[2]For silage storage, the categories on the left are listed in order, with the most important factor for groundwater-

contamination listed first.

[3]Illegal for new-well installation. Existing wells must meet separation requirements in effect at time of construction.

Milking-center wastewater stroage					
No discharge methods					
Milking-center waste water	Waste water delivered directly to liquid-manure storage. No discharge expected.*		Waste water drains outside to grassy area.	Wastewater drains outside to ditch or area with no vegetation.[1]	
*If using this practice, do not complete the rest of the milking-center questions.					
Storage/settling-tank liner	Concrete- or plastic lined.	Clay-lined.	Cracked or porous liner.	No liner to prevent seepage	
Settling-tank cleanout	Tank cleaned as needed.	Tank cleaned every 6 months.	Annual cleaning.	Tank never cleaned.	
Location of discharge					
Distance from drinking-water well	More than 300 feet downslope from well.	300 fee up-slope from well.	Less than 75 feet down-slope from well[1,2]	Less than 75 feet up-slope from well[1,2]	
Use this total to calculate risk ranking in Equation 1.				Total	________

[1]Besides representing a higher-risk choice, this practice also violates Missouri law.
[2]Illegal for new-well installation. Existing wells must meet separation requirements in effect at time of construction.

What do I do with these rankings?

Step 1
Begin by determining your overall well management risk ranking using Equation 1.

Total the rankings for the categories you completed, and divide by the number of categories you ranked:

Equation 1

________ divided by ________ equals ________

(total of rankings) (number of categories ranked) (risk ranking[1])

[1]Carry your answer out to one decimal place.

If your risk ranking is	Your risk is
3.6 to 4	low
2.6 to 3.5	low to moderate
1.6 to 2.5	moderate to high
1 to 1.5	high

This ranking gives you an idea of how your animal-waste management practices **as a whole** might be affecting your drinking water. This ranking should serve only as a **general guide, not a precise diagnosis.** Because it represents an **average** of many individual rankings, it can mask any **individual** rankings (such as 1s or 2s) that should be of concern. (Step 2.)

Enter your animal-waste management risk ranking above in the first table in Worksheet #9 (MU publication WQ659). Later you will compare this risk ranking with other farmstead management rankings. Worksheet #8 (MU publication WQ658) will help you identify your farmstead's site conditions (soil type, soil depth and bedrock characteristics), and Worksheet #9 (MU publication WQ659) will show you how these site conditions affect your risk rankings.

Step 2
Look over your rankings for individual activities:

- **Low-risk practices (4s)**
  ideal; should be your goal despite cost and effort
- **Low- to moderate-risk practices (3s)**
  provide reasonable groundwater protection
- **Moderate- to high-risk practices (2s)**
  inadequate protection in many circumstances
- **High-risk practices (1s)**
  inadequate; pose a high risk of polluting groundwater

Regardless of your overall risk ranking, any individual rankings of "1" require immediate attention. Some concerns you can take care of right away; others could be major — or costly — projects, requiring planning and prioritizing before you take action.

Find any activities that you identified as 1s and list them under "High-Risk Activities" in Worksheet #9 (MU publication WQ659).

Step 3
Read Fact Sheet #7 (MU publication WQ681, *Improving Animal Waste Management*), if you haven't already. Consider how you might modify your farmstead practices to better protect your drinking water.

Animal manure management glossary

These terms may help you make more accurate assessments when completing Worksheet #7. They also may help clarify some of the terms used in Fact Sheet #7 (MU publication WQ681).

- **Concrete stave storage**
  A type of liquid-tight, animal-waste storage structure. Located on a concrete pad, it consists of concrete panels bound together with cable or bolts and sealed between panels.
- **Earthen basin or pit**
  Clay-lined manure-storage facility constructed according to specific engineering standards. Not simply an excavation.
- **Engineering standards**
  Design and construction standards available at Natural Resources Conservation Service (NRCS) or your local MU Extension center. These standards may come from NRCS technical guides, state regulations or land-grant university engineering handbooks.
- **Filter strip**
  A gently sloping grass plot used to filter runoff from the livestock lot. Influent waste is distributed uniformly across the high end of the strip and allowed to flow down the slope. Nutrients and suspended

material remaining in the runoff water are filtered through the grass, absorbed by the soil and ultimately taken up by the plants. Filter strips must be designed and sized to match the characteristics of the livestock lot. Filter strips that discharge effluent from the lower end do not meet Missouri Department of Natural Resources' (DNR) requirements for no-discharge systems and should be considered only in locations where such discharge will not enter a stream, drainage way or surface-water impoundment. In general, filter strips are applicable only to small waste flows containing little or no solids.

- **Glass-lined steel storage**
  A type of liquid-tight, above-ground, animal-waste storage structure. Located on a concrete pad, it consists of steel panels bolted together and coated inside and outside with glass to provide corrosion protection.
- **Infiltration**
  The downward entry of water through the soil surface.
- **Land application**
  Application of wastewater to croplands and pastures by irrigation equipment or a liquid-manure spreader.
- **Perched water table**
  The water table of a saturated soil that is separated from a deeper saturated layer by an unsaturated layer of soil.
- **Percolation**
  The downward movement of water through the soil.
- **Poured concrete storage**
  A type of liquid-tight, animal-waste storage structure. Located on a concrete pad, it consists of poured concrete, reinforced with steel.
- **Runoff control system**
  A combination of management practices that can be used together to prevent water pollution from livestock-lot runoff. Practices may include diversion of runoff from the lot, roof-runoff systems, lot shaping, settling basins and filter strips or buffer areas.
- **Slow surface infiltration**
  Application of wastewater at one end of a gently sloping grass filter strip or terrace so that it is treated as it slowly flows through the plant-soil system. A portion of the flow percolates to groundwater, and some is used by vegetation.
- **Soil drainage class**
  The conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soils, as opposed to human-altered drainage. Different classes are described by such terms as **excessively drained, well-drained,** and **poorly drained**.
- **Soil permeability**
  The quality that enables the soil to transmit water or air. Slowly permeable soils have fine-textured materials, like clays, that permit only slow water movement. Moderately or highly permeable soils have coarse-textured materials, like sands, that permit rapid water movement.
- **Soil texture**
  The relative proportions of the various soil separates (clay, sand, silt) in a soil. Described by such terms as sandy loam and silty clay.
- **Soil-plant filter**
  Pasture or cropland that receives the application of livestock-waste storage effluent. Nitrogen application rate is generally the limiting factor. Periodic removal of plant material by grazing or harvesting is required to prevent buildup of harmful elements in the soil.
- **Surface (overland) flow**
  The process of allowing wastewater to run slowly in a uniform layer over a grass-covered slope and relatively impervious clay soil. There is little percolation into the soil with this method because of the impervious soil. Water eventually flows into runoff-collection ditches (for subsequent discharge).

- **Water table depth**
  Depth to the upper surface of groundwater. This depth is sometimes indicated in the county soil survey, but this varies from county to county. This information may be available from your well construction report or from hydrogeological reports and groundwater-flow maps of your area. Your regional MU Extension agricultural engineering specialist or NRCS district conservationist may be able to help you gather this information. This information also may be obtained through a professional engineer or through the Division of Geology and Land Survey (DGLS) at Rolla, Mo. The phone number for DGLS is 573-364-1752. There are two types of water table:
  - The water table typically noted in a well log as an indication of usable water supply
  - The seasonal high-water table

The seasonal high-water table is important in regard to construction of livestock-manure storage facilities because it may present facility construction problems.

The Missouri Farmstead Assessment System is a cooperative project of MU Extension; College of Agriculture, Food and Natural Resources; and the Natural Resources Conservation Service.

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WQ657, new October 1995

Related MU Extension publications

- WQ650, Farm•A•Syst: An Action Program for Safe Drinking Water
  http://extension.missouri.edu/p/WQ650
- WQ651, Assessing and Reducing the Risk of Groundwater Contamination From Drinking-Water Well Condition
  http://extension.missouri.edu/p/WQ651
- WQ652, Assessing the Risk of Groundwater Contamination From Pesticide Storage and Handling
  http://extension.missouri.edu/p/WQ652
- WQ653, Assessing the Risk of Groundwater Contamination From Fertilizer Storage and Handling
  http://extension.missouri.edu/p/WQ653
- WQ654, Assessing the Risk of Groundwater Contamination From Petroleum Product Storage
  http://extension.missouri.edu/p/WQ654
- WQ655, Assessing the Risk of Groundwater Contamination From Hazardous-Waste Management
  http://extension.missouri.edu/p/WQ655

- WQ656, Assessing the Risk of Groundwater Contamination From Household Wastewater Treatment
  http://extension.missouri.edu/p/WQ656
- WQ658, Reducing the Risk of Groundwater Contamination by Site Evaluation
  http://extension.missouri.edu/p/WQ658
- WQ659, Assessing the Risk of Groundwater Contamination — Overall Farmstead Assessment
  http://extension.missouri.edu/p/WQ659
- WQ660, An Action Program for Safe Drinking Water
  http://extension.missouri.edu/p/WQ660
- WQ675, Reducing the Risk of Groundwater Contamination by Improving Drinking Water Well Conditions
  http://extension.missouri.edu/p/WQ675
- WQ676, Reducing the Risk of Groundwater Contamination by Improving Pesticide Storage and Handling
  http://extension.missouri.edu/p/WQ676
- WQ677, Reducing the Risk of Groundwater Contamination by Improving Fertilizer Storage and Handling
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- WQ680, Reducing the Risk of Groundwater Contamination by Improving Household Wastewater Treatment
  http://extension.missouri.edu/p/WQ680
- WQ681, Reducing the Risk of Groundwater Contamination by Improving Animal Manure Management
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Attachment 21:

Subsurface Drainage and Liquid Manure
(Hoorman and Shipitalo 2006)

SUBSURFACE DRAINAGE AND LIQUID MANURE

By James J. Hoorman and Martin J. Shipitalo

Although land application of liquid animal wastes is a widely used BMP, in fields with subsurface drainage it can result in rapid movement to drains and offsite. In the four-year period, 2000 to 2003, ninety-eight incidents where agricultural wastes in drainage waters contaminated streams were recorded by authorities in Ohio. We investigated these reports to determine the factors that contributed to these incidents and to determine possible management options for reducing their occurrence. Violations occurred most frequently with liquid swine or dairy wastes and with all methods of application-irrigation, surface spreading, and subsurface injection. In most instances multiple factors contributed to each incident. The factor most commonly cited (41 cases) was application to saturated soils or heavy rainfall after application. Thus, avoiding these conditions should reduce the number and severity of incidents. While disruption of soil macropores with tillage may reduce movement of wastes to drains, 17 percent of the incidents occurred on soils that were tilled or wastes were incorporated. Drain line plugs failed 50 percent of the time they were used.

Subsurface drainage improves crop growth and soil productivity, but can have detrimental environmental effects by increasing the movement of agrichemicals to surface water supplies (Kladivko et al., 2001). Frequently, this increased movement is attributed to preferential flow in soil macropores. Factors such as high intensity rainfall, dry soil, and conservation tillage, because it can contribute to the formation and preservation of soil macropores, increase the potential for preferential flow and enhanced chemical transport to occur (Shipitalo et al., 2000).

Liquid animal wastes are a valuable source of nutrients and organic matter for crop production and can be applied by a variety of methods including spray irrigation, surface spreading, and subsurface injection. Because of their low solids and nutrient content, liquid animal wastes are usually applied at relatively high volumes, but it is generally recommended that they not be applied at rates that would exceed the amount needed to bring the soil to field water holding capacity (Johnson and Eckert, 1995). Nevertheless, even when similar guidelines are followed, contamination of drain line effluent has been reported in soils with subsurface drainage due to macropore flow (Geohring et al., 2001).

Table 1. Results of water quality tests downstream, at drainage outlet, and upstream from animal waste spills.

Water Test	Drainage Outlet	Downstream	Upstream	Ohio Standards	Number of Observations
mg/L					
BOD_5	627.3	448.3	3.7	‹15	18
Ammonia N	50.7	44.7	0.9	‹13*	31
Nitrate + nitrate N	8.9	15.3	5.4	‹10	13
TKN	109.7	78.0	2.7	Na	13
Total phosphorus	42.5	34.1	10.5	0.08 to 0.30	22
* Depends on pH and temperature					

The fact that liquid animal wastes can be safely land-applied in some instances, but can cause contamination of subsurface drainage water under different circumstances suggests that soil properties such as texture, initial water content, and tillage history as well as the amount of wastes applied, application method, water content of wastes, and the amount of rainfall after application may all play a role in determining the fate of the applied material.

In Ohio, the state Environmental Protection Agency (OEPA) has imposed substantial fines on producers that contaminate waters of the state when land applying liquid animal wastes. For example, in July 2004 a dairy farm received a $15,000 civil penalty for mishandling liquid wastes (OEPA, 2004). Various agencies keep records of causes and consequences of these types of violations. Therefore, our objective was to compile and examine liquid animal waste spill records for Ohio to determine the extent of the problem and as an aid to help determine conditions that promote contamination. We use this information to suggest methods to reduce the risk of liquid wastes reaching surface waters.

Gathering information

In Ohio, three agencies compile reports on liquid animal waste violations. The Ohio Department of Natural Resources (ODNR) - Division of Wildlife gets most of the calls to investigate reports of wastes in streams, dead fish, and stream littering. In some instances, information is collected by local Soil and Water Conservation Districts, and the OEPA Division of Surface Water collects detailed information on large spills and if legal action is anticipated. Reports from all three agencies were assembled resulting in a database of 98 violations from 1 January 2000 to 31 December 2003 where agricultural wastes entered subsurface drains and contaminated surface waters.

Violations

Fish kills. The death of fish and other aquatic wildlife are attributable to variety of natural and anthropogenic causes. An investigative study by the Dayton Daily News indicated that the number of fish kill incidents from all sources has decreased by 37 percent during the 30-year period from 1973 to 2002. However, the number of incidents attributable to agriculture, has increased by 72 percent in the same time period.

Of the fish kills attributed to agriculture, most are related to livestock production and land application of manure. The value of these fish, assigned by the incident investigators using standardized procedures, ranged from $15 to $65,300 (Figure 1).

Location of incidents. The 98 incidents where manure was found in subsurface drains occurred throughout Ohio (Figure 2). Most of these violations (58) occurred in the relatively flat northwestern part of the state where the soils are poorly drained and subsurface drainage is often required for crop production. The fewest incidents (4) occurred in the hilly southeastern region where systematic subsurface drainage systems are not commonly installed. Of the remaining incidents, 23 occurred in the southwest region and 13 in the northeast. We found some counties and regions were more diligent about reporting manure violations than others.

Characteristics of the livestock operations. Most of the 98 violations occurred on mid-sized swine farms (average of 2,355 head/operation) or large dairy farms (average 556 head/operation) with at least one million gallons (3.8 million liters) of liquid manure storage capacity (Figure 3). This is not surprising as typically these are the type of operations in Ohio that have liquid waste handling systems. Of the 39 operations that had a manure management plan, 28 operations (72 percent) were not following their plans when the violation occurred. The topography was mainly flat (< 6 percent slope) for 62 cases, rolling (> 6 percent slope) in 33 cases, and not reported in 13 cases.

Application timing, method, and rate. Violations occurred most frequently in the months of October-December (35 cases), when manure storage lagoons are typically emptied because the crops have been harvested making land available for application.

Out of the 98-recorded violations, 72 occurred when liquid manure was applied and 76 percent of these were surface applications. Irrigation was the most common method of surface application method, followed by tanker, and dragline. The reported average application rate was 0.59 inches, but this is probably an underestimate as measurements taken by the local SWCD or OEPA investigators indicated that application rates were, on average, two times higher than reported.

Given the uncertainty in application rate it is difficult to estimate the fraction of liquid manure that reached the subsurface drainage network. In ten instances where emergency remediation efforts were performed by the OEPA, however, they recovered 2,700 to more than 500,000 gallons (10,00 to 1,900,000 L) of liquid from the sites (average 86,450 gallons/327,200 L). They estimated that this amount was equivalent to an average of 16 percent (range 2 to 117 percent) of the amount applied. Since this estimate includes liquid wastes that were diluted by water in the ditches and streams it overestimates the actual amount lost and contributes to the high variability in the amount recovered.

Water quality. The data set on quality of the water upstream and downstream from the manure spills only covered a limited number of incidents and a limited set of chemical parameters, but suggested a significant impact on water quality (Table 1).

Reasons for incidents. Regardless of whether mismanagement occurred, preferential flow of the liquid wastes to subsurface drains via soil macropores was a major contributing factor to off-site movement of contaminants associated with liquid waste application. The reports indicated that soil cracks and earthworm burrows were cited as contributing factors in 21 percent of the incidents (Table 2). Tillage has been advocated as a method to disrupt macropore continuity and reduce losses of liquid wastes via subsurface drainage systems and a number of studies support this recommendation. In a laboratory study, Cook and Baker (2001)

Figure 1.
Officials quantifying the number of fish killed as a result of subsurface drainage discharge in Union County, Ohio. Courtesy of OEPA.

noted movement of water and bacteria associated with application of liquid swine wastes was reduced by tillage. Similarly, Jamieson et al. (2002) noted that tillage reduced bacterial transport. When they disked the soil prior to the application of liquid swine wastes Kay et al. (2004) noted that peak antibiotic concentration in drain flow was reduced by two orders of magnitude compared to application to standing crop stubble. Both Geohring et al. (2001) and Randall et al. (2000) noted that incorporation of liquid manure reduced phosphorus transport and Geohring et al. (2001) recommend plowing and avoiding application when rainfall is imminent as best management practices.

In 57 of the 98 incidents we investigated either the soil was not tilled or the liquid wastes were not incorporated, but in 14 cases tillage or incorporation were documented in the reports. Tilling the soil in a narrow band above the subsurface drains or avoiding waste application in this zone have been suggested as management options to reduce movement to tile lines (Shipitalo and Gibbs, 2000). Tillage will probably reduce movement of liquid wastes to subsurface drains, but it is not likely to eliminate it in all situations based on the incidents we investigated and the studies conducted by other researchers. Similarly, avoiding application in a relatively narrow zone above the sub-drains will probably not be entirely effective as recent studies have suggested that solutes and particulate matter can move laterally up to several yards (meters) in the near surface soil horizons before moving downward in preferential flow paths in tilled soils (Shipitalo et al., 2004) and in grassland (Stamm et al., 2002). In both these studies earthworm burrows were implicated as the dominant preferential flow paths leading from the near surface to the sub-drains, but in other soils cracks can assume this role (Kladivko et al., 2001; Simard et al., 2000).

Drain line plugs and catch basins as control measures. Once liquid wastes have entered a subsurface drainage system it is essential that it be prevented from being discharged into surface waters. One method of doing this is to install drain line plugs or stops at the outlets. These efforts failed often. Thus, plugs and stops should probably only be used on subsurface drainage systems that have been designed to minimize bypass and only then as an emergency measure when all other management options have been exhausted.

An alternative control measure is to permanently install shut-off valves and catch basins in the subsurface drainage system to capture any effluent before it enters the surface water supplies. Properly designed, these should be less prone to failure than drain plugs and stops alone. Additionally, they can serve as a tool for monitoring, managing, and cleaning up liquid wastes that get into subsurface drainage systems. Although this practice should help to control the problem when liquid wastes enter drainage systems immediately upon land application, this measure would be not practical when the drain lines are flowing at the time of application or when rainfall after waste application causes drain flow to occur and mobilizes waste-derived contaminants in the soil or drainage system. Currently, in Ohio, cost share funds are available for plugs and catch basins.

Table 2. Reasons why liquid animal wastes entered subsurface drains in Ohio (2000 to 2003).

Cause	Number of cases out of 98
Excess Rain or saturated Soils	41
Over application or application error	35
Manure storage management	33
Ponding manure or excessive irrigation	26
Drainage lines flowing or plug failure	20
Broken tile or shallow drainage	14
Equipment or storage failure	13
Dry, cracked soils	13
Feedlot runoff	11
Snowmelt	10
Eggwash water (thin waste, low solids)	10
Earthworm burrows	8

In conclusion

Although fish kills have declined dramatically in Ohio during the past 30 years, fish kills attributable to agriculture have increased during this time period. Most of the events attributable to agriculture are linked to livestock and manure management issues. Surface water contamination related to application of liquid animal wastes to soils with subsurface drainage systems has been a major contributor to this problem.

Our investigation of 98 animal waste spill records for 2000 thru 2003 indicated that while this problem has been noted in all regions of the state, most of the incidents occurred in northwestern Ohio where subsurface drainage systems and large confined animal feeding operations are common. Since soil, climatic, and farm operations in this area typify conditions in much of the Midwest, our results suggest widespread occurrence of this problem throughout the region.

In many of the cases, mismanagement and failure to have and follow a manure management plan probably contributed to the severity of the violation. Nevertheless, violations occurred even when approved procedures were followed.

The most common contributing factor was application to saturated soils or rain after application. Thus, a key component to reducing the number of violations is to avoid applying liquid

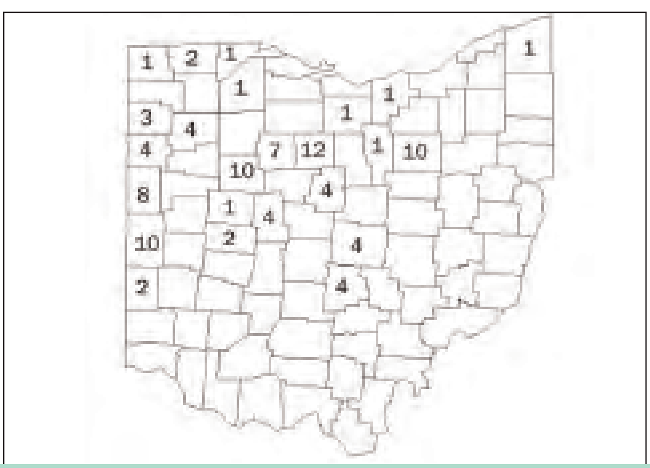

Figure 2.
Distribution of 98 incidents where animal wastes contaminated subsurface drainage effluent in the 88 counties of Ohio.

wastes shortly before or after heavy rainfall and particularly when drain lines are flowing. Achieving this objective may entail increasing waste storage capacity, regular monitoring of amounts stored, and advanced scheduling of application equipment and custom applicators.

The next largest contributing factors were manure storage management and over application of liquid manure. Farm operators failed to adequately manage their manure storage structures or give themselves enough time to apply the manure in a timely manner.

While the results of our study and other research suggest that tillage and incorporation of liquid waste can reduce the potential for movement to subsurface drains in soil macropores, tillage is not a panacea. Violations occurred even when wastes were applied to tilled soil. The soil probably needs to be tilled to a seedbed condition to a depth of at least 3 inches (76 mm) before surface application or 3 inches (76 mm) below the depth of injection just before liquid wastes are applied in order to disrupt macropores and prevent preferential flow. This intensity of tillage is probably not practical in many situations and would have the undesirable consequence of eliminating the soil and water quality benefits of conservation tillage practices. Drain line stops should only be used as an emergency measure and in instances where the systems have been modified for their use.

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Figure 3.
Contamination of subsurface drainage effluent attributable to heavy rainfall following application of liquid swine manure to an untilled, corn silage field in Darke County, Ohio. Analysis of the effluent indicated a BOD_5 of 3200 mg/L, 205 mg NH_4-N/L, 9.0 mg NO_3-N + NO_2-N/L, and 174 mg total P/L. Courtesy of OEPA.

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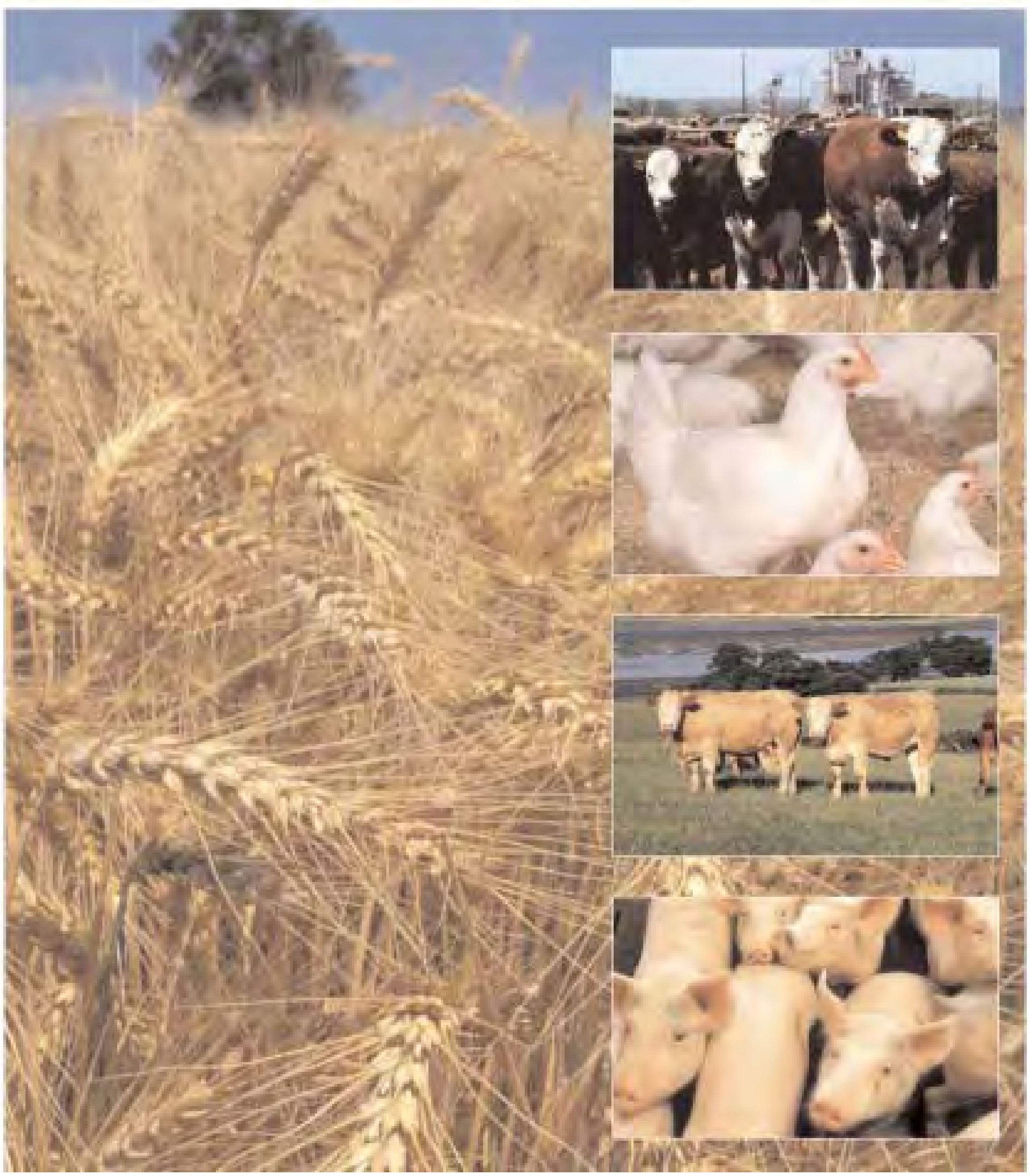
Attachment 22:

Managing Manure Nutrients at Concentrated Animal Feeding Operations
August 2004

EPA
United States
Environmental Protection
Agency

Managing Manure Nutrients at Concentrated Animal Feeding Operations

August 2004



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EPA-821-B-04-006

Disclaimer

This is a guidance manual and is not a regulation. It does not change or substitute for any legal requirements. While EPA has made every effort to ensure the accuracy of the discussion in this guidance, the obligations of the regulated community are determined by the relevant statutes, regulations, or other legally binding requirements. This guidance manual is not a rule, is not legally enforceable, and does not confer legal rights or impose legal obligations upon any member of the public, EPA, States, or any other agency. In the event of a conflict between the discussion in this document and any statute or regulation, this document would not be controlling. The word “should” as used in this guidance manual does not connote a requirement, but does indicate EPA’s strongly preferred approach to assure effective implementation of legal requirements. This guidance may not apply in a particular situation based upon the circumstances, and EPA, States and Tribes retain the discretion to adopt approaches on a case-by-case basis that differ from this guidance manual where appropriate. Permitting authorities will make each permitting decision on a case-by-case basis and will be guided by the applicable requirements of the CWA and implementing regulations, taking into account comments and information presented at that time by interested persons regarding the appropriateness of applying these recommendations to the particular situation. In addition, EPA may decide to revise this guidance manual without public notice to reflect changes in EPA’s approach to implementing the regulations or to clarify and update text.

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CHAPTER 1: INTRODUCTION

A. Purpose of this Document

In early 2003, EPA issued significant revisions to its regulations for NPDES permitting of concentrated animal feeding operations ("CAFOs") under the Clean Water Act. In December, 2003, EPA issued a guidance document for CAFO permitting titled "NPDES Permit Writers' Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations," EPA-833-B-04-001 ("Permit Guidance"). That guidance document discussed the general framework for NPDES permitting of CAFOs under the Clean Water Act and EPA's revised regulations. It addressed such issues as when does an animal feeding operation become defined as a CAFO, when are CAFOs required to get a permit, the difference between general permits and individual permits, and what effluent limitations and standards should or must be included in NPDES permits for CAFOs.

This document, "*Managing Manure,"* is designed to supplement EPA's previous guidance by providing additional technical information to owners, operators, technical service providers, consultants, and permit authorities on how to carry out EPA's revised regulatory requirements for NPDES permitting of CAFOs. It also provides information on voluntary technologies and management practices that may both improve the production efficiency of CAFOs and further protect the quality of the nation's waters. This document assumes that readers have a basic understanding of the CAFO regulations.

B. Scope of this Document

EPA's regulations governing CAFOs consist primarily of two different sets of regulations. First, the regulations at 40 CFR 122.23 set the framework for CAFO permitting by establishing criteria for who is defined as a CAFO and specifying whether, and when, a CAFO must apply for a permit. The second set of regulations, which are at 40 CFR Part 412, are the effluent limitations guidelines and standards ("ELGs" or "effluent guidelines") for CAFOs, which establish discharge limits and certain management practice requirements that must be included in NPDES permits for CAFOs.

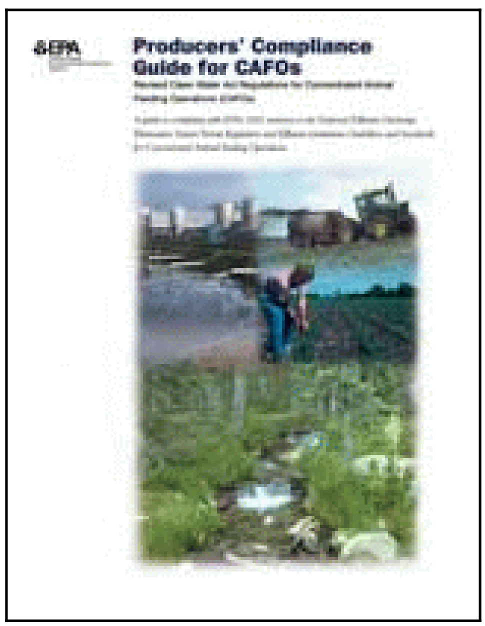
While the regulations at 40 CFR 122.23 apply to all operations, it should be noted that the ELG requirements in 40 CFR Part 412 apply only to permitting of Large CAFOs, as that term is defined in the regulations. The statements below on what is *required* under the ELGs therefore apply only to the permitting of Large CAFOs. For permitting of Medium and Small CAFOs, permitting authorities will set effluent limitations on a case-by-case basis based on site-specific conditions. Where deemed appropriate by the permitting authority, the permitting authority may set effluent limitations for those CAFOs that are similar to the ELG requirements for Large CAFOs. EPA encourages permitting authorities to consider the discussions below on the requirements and recommendations for applying the ELG to Large CAFOs when establishing permit conditions for CAFOs of any size.

C. How To Use this Document

Managing Manure contains information pertinent to <u>Large CAFOs</u> in the *Dairy Cows and Cattle other than Veal Calves* and the *Swine, Poultry, and Veal Calves* subcategories of the final CAFO regulations (see Section E of this chapter). Permit writers, at their discretion on a case-by-case basis, may want to consider the information in this manual pertinent to small and medium CAFOs. The effluent guidelines requirements cited in this manual must be included in permits for Large CAFOs, while the permit writer <u>may</u> include them in permits for smaller CAFOs at the permit authority's discretion. This manual assumes readers have a basic understanding of the CAFO regulations. Text boxes in each section provide the relevant regulatory language, additional clarifications, and examples for key concepts.

Managing Manure is organized into eight chapters and 15 appendices:

- Chapter 2 identifies and discusses the production area requirements of the CAFO rules, example technologies that may help a facility comply with the production area requirements, and additional voluntary practices that may benefit operators of many Large CAFOs.
- Chapter 3 identifies the requirements prior to land application of manure, litter, and process wastewater (i.e., manure sampling and recordkeeping if these wastes are transferred off site).
- Chapter 4 describes the land application area requirements of the CAFO rules (including the Nutrient Management Plan, setback requirements, and recordkeeping) example management practices that may be used to help comply with the land application area requirements, and additional voluntary practices that may benefit operators of most Large CAFOs.
- Chapter 5 describes the goals and requirements of the voluntary alternative performance standards for CAFOs, including several detailed case studies that may help CAFOs and Permit Authorities develop their own voluntary alternative performance standards.
- Chapter 6 provides guidance and case studies for the development and use of Technical Standards for land application.
- Chapter 7 describes the most common deficiencies found at CAFOs, identifies practices to help avoid them, and includes some case studies of management practices CAFOs may use to help achieve compliance with the CAFO regulations.
- Chapter 8 lists resources for additional help in complying with the regulations.
- This document also includes several appendices including the regulations found at 40 CFR, sample inspection checklists, records checklist, sample calculations, and example methods for manure sampling, and equipment calibration. These examples are not binding or required, they are examples of how some Permit Authorities have implemented the regulatory requirements.



To further assist the user of this document, text boxes in each section provide the relevant regulatory language, additional clarifications, and examples for key concepts. Regulatory citations are provided in text boxes with a double line. Examples and clarifications are denoted by text boxes with a single line.

D. Other Related Documents

The *Producer's Guide (Producers' Compliance Guide for CAFOs*, EPA, 2003) gives a general description of the revised CAFO regulations and helps an animal feeding operation (AFO) determine whether they might be regulated under the revised regulations.

The *Permit Guidance (Permit Writers Guidance Manual and Sample NPDES Permit for Concentrated Animal Feeding Operations*, EPA, 2003) provides information to NPDES permit writers on the permitting requirements for CAFOs. This *Permit Guidance* is accompanied by a series of questions and answers that reiterate the regulatory requirements and provide additional clarity by referring to corresponding sections of the CAFO final preamble.

Because they do not describe in detail the full set of federal regulatory requirements for CAFOs or the pertinent State requirements, neither the *Producer's Guide* nor the *Permit Guidance* are intended to be used to ensure that a CAFO is in compliance with all applicable requirements. Readers are further cautioned that any of these guidance documents may be revised or amended without notice.

EPA's National Agriculture Compliance Assistance Center (http://www.epa.gov/agriculture/) provides information on environmental requirements affecting the agriculture industry, including links to resources and publications. This web site is continually updated.

Chapter 8 of this document provides additional resources.

E. Scope of CAFO Regulations

The federal regulatory requirements for CAFOs consist of Effluent Limitation Guidelines and Standards for the CAFOs point source category (40 CFR Part 412), and NPDES permitting requirements for CAFOs (40 CFR Part 122). In 2003, EPA revised both the effluent guidelines and NPDES permitting requirements for CAFOs. Among other things, the new regulations establish manure management performance standards for new and existing CAFOs. Any NPDES permit issued to a CAFO after April 14, 2003 must contain the revised effluent guidelines at 40 CFR Part 412. Appendix A of this document contains a copy of these final rules. CAFOs should read these federal regulations as well as any state regulations for CAFOs, and should check with the agency that regulates CAFOs in that state to determine permitting requirements. For more information on EPA's regulatory authority for the CAFO regulations, see Section 1 of the *Final CAFO Preamble* and Chapter 1 of the *Development Document for the Final Revisions to the NPDES and the Effluent Guidelines for Concentrated Animal Feeding Operations*, available at <www.epa.gov/npdes/caforule>.

The NPDES permitting regulations generally define an AFO, among other things, as an operation where livestock or poultry are confined for an extended period of time (see 40 CFR 122.23 (b)(1) for the legal definition). This definition is intended to differentiate confinement-based operations from pasture-based operations, where the latter are intended to be excluded from the CAFO regulations.

> **AFO Definition**
>
> **§122.23 (b)(1)** Lot or facility (other than an aquatic animal production facility) where animals (other than aquatic animals) have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period:
>
> *AND*
>
> Where crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

An operation is a Large CAFO if it meets the definition of an AFO ***and*** it confines at least:

- 700 mature dairy cows;
- 1,000 beef cattle or heifers;
- 1,000 veal calves;
- 2,500 swine (each 55 pounds or more);
- 10,000 swine (each under 55 pounds);
- 30,000 chickens (liquid manure handling systems);
- 125,000 chickens except laying hens (other than liquid manure handling systems);
- 82,000 laying hens (other than liquid manure handling systems);
- 55,000 turkeys;

- 5,000 ducks (liquid manure handling systems);
- 30,000 ducks (other than liquid manure handling systems);
- 500 horses; or
- 10,000 sheep or lambs.

The CAFO regulations also use the terminology "Medium CAFOs" and "Small CAFOs;" these terms are generally not used in this document. For more information on the definition of a CAFO, consult the *Permit Guidance* as well as Chapter 2 of the *Development Document for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations*. Both of these documents can be found on the Internet at <www.epa.gov/npdes/caforule>.

The effluent guidelines referred to in this document vary depending on whether the CAFO is currently operating at the time that the regulations were revised or if construction of the operation began after April 14, 2003. Newly constructed CAFOs, and certain CAFOs expanding the size of their operation may be subject to more stringent requirements known as New Source Performance Standards (NSPS). For more information consult the *Permit Guidance* as well as the guidance memorandum entitled "New Source Determinations for Direct and Indirect Dischargers" and 2004 memorandum entitled "Clarification Regarding CAFOs in 10-Year Protection Period."

The effluent guidelines are broken into the following subparts, each addressing specific animal sectors:

- Subpart A: Horses and Sheep;
- Subpart B: Ducks;
- Subpart C: Dairy Cows and Cattle other than Veal Calves; and
- Subpart D: Swine, Poultry, and Veal Calves.

Managing Manure focuses only on the animal operations with new or revised effluent guidelines, specifically Subparts C and D (beef cattle, dairy cattle, veal calves, swine, chickens, and turkeys). Though the effluent guidelines for horses, sheep, and ducks have not changed, these facilities may be subject to revised or additional requirements under the revised NPDES permitting requirements for CAFOs at 40 CFR Part 122. Even for AFOs that are not regulated as CAFOs, EPA encourages all owners and operators of those AFOs to review the practices described in this guidance manual and consider adopting those practices that are applicable to their operation.

F. CAFOs with No Potential to Discharge

The NPDES CAFO regulations require all CAFOs to apply for a permit. EPA recognizes that, although they may be infrequent, there may instances where a CAFO truly does not have a potential to discharge. Therefore, an exception is that in lieu of a permit application, Large CAFOs can request a "no potential to discharge" determination from the permitting authority where there is no potential for any CAFO manure, litter, or process wastewater to be added to waters of the United States under any circumstances or climatic condition. If the permitting authority makes a determination that the CAFO has "no potential to discharge", the operation would not need to apply for an NPDES permit. Land application discharges from a CAFO are subject to NPDES requirements. It is important to note that the "no potential to discharge" determination applies to both the production area and land application areas under the control of the CAFO. The "no potential to discharge" determination process may include a site visit to verify the information submitted by the CAFO operator or to gather additional information necessary to make the determination. See Figure 1-1 for an example CAFO that might be able to make a demonstration of no potential to discharge.

For more information on supporting a request for a "no potential to discharge" determination, see section 3.3.5 of the *Permit Guidance*, available on the internet at http://www.epa.gov/npdes/pubs/cafo_permit_guidance_chapters.pdf

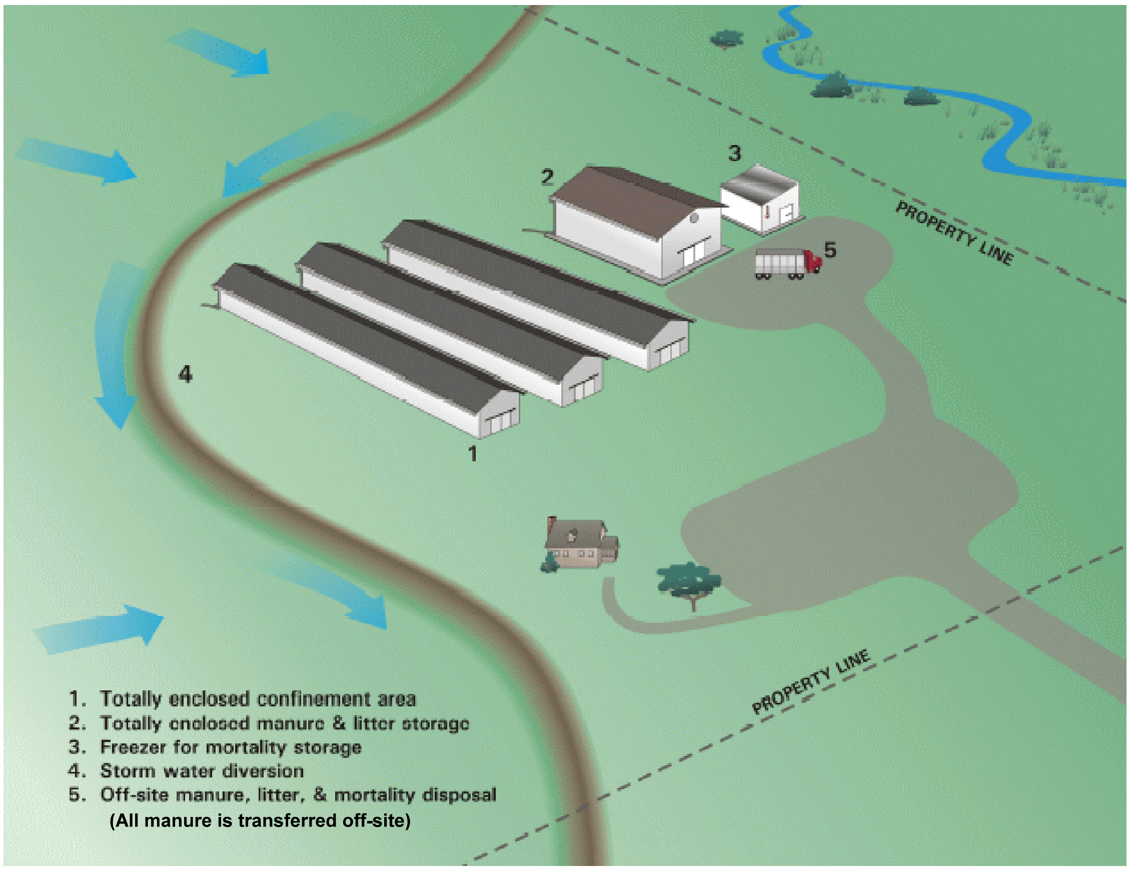


Figure 1-1. Example CAFO Potentially Demonstrating No Potential to Discharge

G. Comments on *Managing Manure*

This document may be revised or amended periodically without public notice. EPA welcomes public comments on this document at any time, and will consider those comments in any future revision of this document. Comments, including additional helpful information, may be submitted electronically to Paul Shriner at shriner.paul@epa.gov, or mailed to:

U.S. EPA
Engineering and Analysis Division 4303T
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Figures

CHAPTER 2: OPERATION, MAINTENANCE, AND RECORDKEEPING REQUIREMENTS FOR THE PRODUCTION AREA

This chapter discusses the operation, maintenance, and recordkeeping requirements for a CAFO *production area*. The production area at a CAFO includes the *animal confinement area*, the *manure storage area*, the *raw material storage area*, and the *waste containment area*. It also includes areas where eggs are washed or processed and areas used for the storage, handling, treatment, or disposal of dead animals (i.e., mortalities). Throughout this chapter, "manure" means manure, litter, and manure combined with other process wastewaters. The terms "process wastewaters," "production area," and "land application area" are also used throughout this chapter. The effluent guidelines described in this chapter apply only to Large CAFOs. The NPDES requirements apply to all CAFOs. This document uses "CAFO rules" to mean both the effluent guidelines and the NPDES permit requirements. Permit writers, at their discretion on a case-by-case basis, may want to consider the information in this chapter pertinent to small and medium CAFOs on a case-by-case basis. The legal definitions are provided in the text box on the next page.

Photo by USDA NRCS

Runoff from raw material storage such as silos and feed bunkers is included in the definition of process wastewater, and must be handled to meet the effluent guidelines production area requirements. Some examples of water that come into contact with raw materials, products, or byproducts include water that comes into contact with spilled feed, contaminated milk, spent foot bath water, and other trace quantities of chemicals used at the operation.

Production areas include all of the following:

- *Animal confinement area* - area within a CAFO where animals are confined for a period of time for feeding or maintenance purposes.
- *Manure storage area* - area where manure and other wastes (e.g., bedding, compost, raw materials commingled with manure, or flush water) collected from the animal confinement area are stored or treated prior to final disposal.

- *Raw-materials storage area* - area where materials used in an animal feeding operation are stored.

- *Waste containment area* - area where wastes other than manure (e.g., contaminated storm water) from the production area are contained prior to final use or disposal.

All field storage and stockpiles of manure and raw materials are defined as production area. A CAFO may have more than one production area. For example, a poultry operation may have long term litter storage sheds or stockpiles (*manure storage areas*) that are remotely located from the poultry houses (*animal confinement areas*); or a CAFO may handle mortalities at an area remotely located from the animal confinement area. The CAFO requirements apply to all such production areas.

The definition of "production area" makes no distinction between short-term or temporary storage areas. Note in particular, however, that at layer and broiler operations, whether uncovered stockpiles of litter exist only temporarily or for a longer period of time *can* make a difference as to the facility's regulatory status. At these operations, uncovered stockpiles of litter generally constitute a "liquid manure handling system," and operations with a liquid manure handling system are defined in the regulations as Large CAFOs at a lower threshold number of animals than other operations. However, the permit authority may authorize some limited period of no more than 15 days for temporary storage of litter (e.g., where this time is needed to allow for contract hauling arrangements), within which time the uncovered stockpile of litter would not be deemed to be a liquid manure handling system. See Chapter 1 of this document and section 3.2.3 of the *Permit Writers' Guidance* for more information.

Process Wastewater, Production Area, and Land Application Definitions

§412.2(d) Process wastewater means water directly or indirectly used in the operation of the CAFO for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning, or flushing pens, barns, manure pits, or other CAFO facilities; direct contact swimming, washing, or spray cooling of animals; or duct control. Process wastewater also includes any water which comes into contact with any raw materials, products, or byproducts including manure, litter, feed, milk, eggs, or bedding.

§412.2(h) Production area means that part of an AFO that includes the animal confinement area, the manure storage area, the raw materials storage area, and the waste containment areas. The animal confinement area includes but is not limited to open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milkrooms, milking centers, cowyards, barnyards, medication pens, walkers, animal walkways, and stables. The manure storage area includes but is not limited to lagoons, runoff ponds, storage sheds, stockpiles, under house or pit storages, liquid impoundments, static piles, and composting piles. The raw materials storage area includes but is not limited to feed silos, silage bunkers, and bedding materials. The waste containment area includes but is not limited to settling basins, and areas within berms and diversions which separate uncontaminated storm water. Also included in the definition of production area is any egg washing or egg processing facility, and any area used in the storage, handling, treatment, or disposal of mortalities.

§412.2(e) Land application area means land under the control of an AFO owner or operator, whether it is owned, rented, or leased, to which manure, litter, or process wastewater from the production area is or may be applied.

The production area definition does not include the owner/operator's office or homestead, and does not include the field areas to which manure and process wastewater may be applied as nutrients for crop growth. See Figure 2-1 for an illustration of a dairy; the production area is indicated by the dashed line.

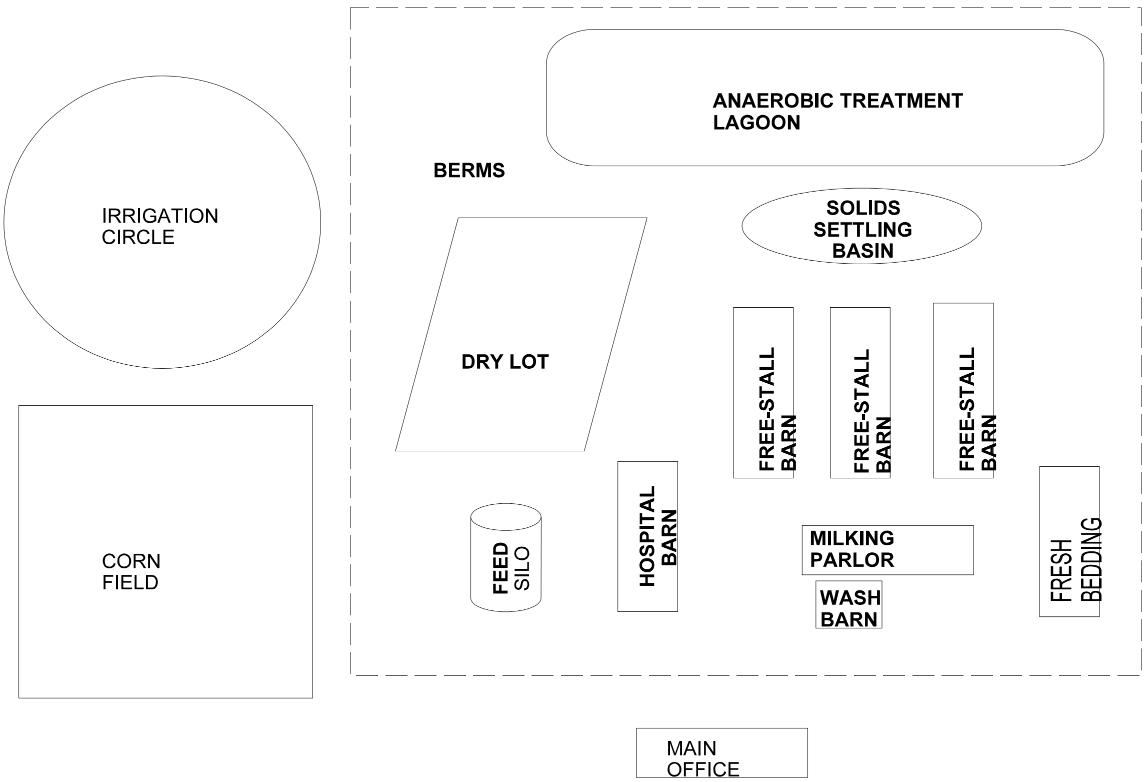


Figure 2-1. Production Area at Whole Milk Dairy

As a standard NPDES permit condition (see Section A of this chapter), all CAFOs are required to properly operate and maintain all facilities and systems of treatment and control which are installed or used to achieve compliance with the conditions of their permit. See 40 CFR 122.41(e). In addition, the CAFO rules require each CAFO to have a Nutrient Management Plan (NMP) which must include, to the extent applicable, a set of nine minimum practices, including the following specific activities that apply to the operation and maintenance of a CAFO production area (see 40 CFR 122.42(e)):

- Ensure adequate storage for manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facilities;
- Ensure proper management of mortalities (i.e., dead animals) to ensure that they are not disposed of in a liquid manure, storm water, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities;
- Ensure that clean water is diverted, as appropriate, from the production area;

- Prevent the direct contact of confined animals with waters of the United States;
- Ensure that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or storm water storage or treatment system unless specifically designed to treat such chemicals and other contaminants;
- Identify appropriate site-specific conservation practices to be implemented, including as appropriate buffers or equivalent practices, to control runoff of pollutants to waters of the United States;
- Identify protocols for appropriate testing of manure, litter, process wastewater, and soil;
- Establish protocols to land apply manure, litter, or process wastewater in accordance with site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter, or process wastewater; and
- Identify specific records that will be maintained to document the implementation and management of the minimum elements described above.

The following sections elaborate on each of these activities by describing both the required NPDES conditions as well as the applicable requirements from the effluent guidelines. The remainder of this chapter covers the CAFO's requirements for the following topics: design standards, proper operation and maintenance, mortalities, direct contact, chemical disposal, records, and additional voluntary controls.

A. Design Standards

> **Additional Conditions Applicable to CAFOs**
>
> **§122.42(e)(1)(i)** Ensure adequate storage of manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facilities.

The CAFO rules prohibit the discharge of manure, litter, and other process wastewaters from the production area, except for allowing a discharge when rainfall causes an overflow from a storage structure designed, constructed, maintained, and operated to contain all manure, litter, and process wastewaters, including storm water, plus runoff and the direct precipitation from a 25-year, 24-hour rainfall event. By requiring adequate storage (see 40 CFR 122.42(e)(1)(i)) plus the capacity for 25-year, 24-hour rainfall event (see 40 CFR 412.31(a)(1)(i)), the CAFO rules help to ensure that discharges of manure from a production area to waters of the U.S. are minimized or eliminated. At the same time, the CAFO rules provide a CAFO that has properly designed, constructed, maintained, and operated its facility with an allowance under its permit for a discharge from the production area in the case of uncontrollable rainfall events (see Example 2-1).

Example 2-1. Design Standards that Comply with the Clean Water Act

A permitted CAFO's waste handling system has the capacity to contain the expected volume of runoff from a 25-year, 24-hour rainfall event plus four month's worth of average daily process wastewater. Note that the definition of "process wastewater" includes contaminated runoff (see 40 CFR 412.2(d)). An unusually long and wet winter precludes the operator from dewatering the storage facility. It rains heavily for three weeks (a chronic rainfall), but the rainfall in any 24-hour period never exceeds the 25-year, 24-hour storm event. The facility's waste handling system reaches capacity and the resulting overflow discharges to a river.

Did the CAFOs violate its permit?

If the CAFO met the requirements of its permit regarding the design, construction, operation and maintenance of its waste handling system this overflow due to a chronic rainfall event, but less than the 25-year, 24-hour storm, is not a violation of the permit. To ensure that it is meeting the requirements of the permit, the CAFO may want to check with its permitting authority to verify that the design capacity it has chosen is adequate. For example, the permit authority may require additional design capacity to meet Water Quality Standards.

1. Adequate Storage for Manure, Litter, and Process Wastewater

CAFOs must ensure adequate storage of manure, litter, and process wastewater, including procedures to ensure proper operation and maintenance of the storage facilities (see 40 CFR 122.42(e)(1)(i)). Having adequate storage for all manure and wastewater provides flexibility to schedule land application of manure nutrients when weather and field conditions are suitable and when nutrients in the manure can best be used by crops. The link between adequate storage and land application practices is one of the most critical considerations in successfully developing and implementing a site-specific Nutrient Management Plan. In fact, the capacity for the 25-year, 24-hour storm event (or the 100-year, 24-hour storm, where appropriate) is just one component in determining overall storage capacity. Equally important is to ensure the capacity needed to store manure and wastes during those periods when land application is prohibited under a states' technical standards (see Chapter 4). Adequate storage will help CAFOs meet the land application practices specified in their NMP, the best management practices required for land application of manure and process wastewater, and will help CAFOs meet realistic production goals while minimizing nitrogen and phosphorus movement to surface waters, as required by the effluent guidelines for Large CAFOs (40 CFR 412.4(c)(1)). See Chapter 4 of this manual for more information on Nutrient Management Plans and land application requirements. See *Cost Methodology for the Final Revisions to the NPDES and Effluent Guidelines for CAFOs* (EPA 821-R-03-004) and *Development Document for the Final Revisions to the NPDES and Effluent Guidelines for CAFOs* (EPA 821-R-03-001) for additional information on adequate storage.

Adequate storage is not defined by the CAFO regulations. Adequate storage is based on a site-specific evaluation of the CAFO's entire waste handling system. Factors such as rainy seasons and storage capacity for the winter are relevant and are readily factored into the proper design and construction of any storage facility; see Example 2-2A. Also see Section B.1 of this chapter: Liquid Storage Structures and the accompanying text box on chronic rainfalls. Adequate storage is also affected by the individual CAFO's operation and maintenance schedule and the site-specific Nutrient Management Plan; see Example 2-2B. CAFOs should also evaluate storage capacity and the adequacy of the existing waste handling system when the facility undergoes significant changes such as an expansion of herd size; see Example 2-2C. CAFOs should further ensure that storage is adequate to avoid pumping water at a non-optimal time to apply nutrients; see Example 2-2D. An example state regulatory requirement that defines adequate storage to include capacity for the winter plus freeboard is in Example 2-2E.

For additional information on designing, operating, and maintaining a storage structure, see U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Practice Standards 313, *Waste Storage Facility,* and 359, *Waste Treatment Lagoon,* and the Field Office Tech Guide. These practice standards include information on the foundation of the storage pond or lagoon, maximum operating levels, structural loadings for fabricated structures, slab designs, and considerations for minimizing the potential for and impacts of sudden breach of embankment or accidental release from the required volume. These resources are described in more detail in Chapter 8 of this document.

The CAFO rules do not have specific design requirements for how to choose a site for storage structures, or that site's effect on the design of storage structures. However, CAFOs should evaluate the soils, geology, and topography of the site, as well as the location and layout of the operation to determine the best storage area for each operation. Animal manure storage areas should be built following commonly approved standards (e.g., USDA NRCS standards, American National Standard for Good Environmental Livestock Production Practices (ANSI GELPP)[1]) and should be located away from water bodies, floodplains, drinking water wells, shallow ground water, sinkholes, and other environmentally sensitive areas. These standards also recommend that the production area is located with adequate separation distances from neighbors to minimize visual exposure and disrupt airflow. Where adequate separation is not possible, consider installing natural or manmade screening.

Example 2-2. Examples of Site-Specific Determination of Adequate Storage

Example A: **Capacity for the wet season.**€
A feedlot is located in a southern climate where the typical winter is brief and mild. Manure solids are€ separated daily and picked up monthly by a third party hauler. The CAFO schedules wastewater€ irrigation every 21 days to empty the holding pond unless the ground is wet or it is raining at the time of€ scheduled irrigation. The CAFO constructed the holding pond for 21 days of storage. Historical€ records show during the rainy season it typically rains daily for 45 days and the ground remains wet for€ approximately three months. €

[1]The ANSI GELPP standards are a compilation of management practices that are commonly applied throughout confined livestock production operations. For additional information on siting, see ANSI GELPP 0001-2002. For additional information on measures that can be taken to reduce adverse environmental impacts of CAFOs, see ANSI GELPP 0002-2002.

Example 2-2. Examples of Site-Specific Determination of Adequate Storage

Does the CAFO meet the adequate storage requirements?

No, the CAFO does not have adequate storage. When designing the holding pond, the CAFO did not consider the typical length of time (i.e., three months) that is required during the rainy season between emptying events. The CAFO should consider a more proactive operation and maintenance program to maintain capacity for the 25-year, 24-hour rainfall event.

Example B: **Capacity Consistent with NMP**
A poultry CAFO has a storage shed that can store the manure and litter removed from the poultry houses between each flock (i.e., manure "crust" or "cake"). The remaining manure and litter (i.e., the full house cleanout) is removed from the poultry houses once a year in the fall and stockpiled outside (the capacity of the shed cannot store a full-house cleanout). The practice does not coincide with the nutrient needs of the crops, and does not minimize the transport of nutrients from the crop fields. Rather than build additional storage or maintain covered temporary stockpiles, the CAFO coordinates with their integrator and arranges for full-house cleanouts to coincide with nutrient needs of the crops <u>in the spring</u>. Under the CAFO's Nutrient Management Plan, 100% of the CAFOs manure and litter is to be used for land application. The CAFO has adequate land for all manure and litter produced. These practices and procedures are specified in the CAFO's revised Nutrient Management Plan. The CAFO's records and inspections show complete implementation of the Nutrient Management Plan.

Does the CAFO meet the adequate storage requirements?

The CAFO's revised NMP includes spring cleanouts instead of fall cleanouts. Generally, the CAFO would be considered to have adequate storage.

Example C: **Adequate Capacity for Facility Expansion**
A 900 head dairy increases production by expanding the herd size to 1,200 head. The CAFOs original treatment lagoon was sized for 900 head.

Does the CAFO meet the adequate storage requirements?

No, the CAFO does not have adequate storage. The lagoon was neither sized nor designed to treat the manure and process wastewater for an additional 300 head. In addition, the lagoon may now experience operational problems due to overloading the treatment system, and may also experience significant increases in odors.

Example D: Adequate Capacity for Appropriate Utilization of Nutrients
A 1,500 head beef feedlot is located in a mild climate, and the state's technical standards do not prohibit land application in the winter. The CAFO has a highly efficient solids separation system, a concrete holding pad for solids storage during inclement weather, and applies the manure solids as fertilizer in accordance with a Nutrient Management Plan. Any wastewater and runoff is directed to an evaporation pond sized solely for runoff from the 25-year, 24-hour storm event. Every year during the rainy season the wastewater accumulates until rainfall events fill the evaporation pond, overflows across a field, and discharges to a river.

Does the CAFO meet the adequate storage requirements?

No, the CAFO does not have adequate storage. The CAFO has not appropriately addressed the pollutants in the wastewater. The CAFO does not have capacity for all manure and process wastewater, including the runoff and direct precipitation from a 25-year, 24-hour rainfall event. In addition, the lack of adequate storage capacity contributed to the CAFO's failure to ensure that manure application to fields was restricted to rates that would minimize phosphorus and nitrogen transport from

Example 2-2. Examples of Site-Specific Determination of Adequate Storage

the fields to waters of the U.S. (see 40 CFR 412.4(c)(1)). For example, the feedlot's design is such that the facility cannot store process wastewater during those periods when the fields are saturated. Furthermore, the annual occurrence of discharges from the CAFO's wastewater storage pond suggests the CAFO has not appropriately considered the rainy season in the design and construction of the pond.

Example E: Sample State Regulation to Define Adequate Storage
Storage structures containing manure with less than 20% total solids and exposed to precipitation must maintain a minimum freeboard of **one foot** at all times. This is in addition to the capacity needed to contain direct precipitation and runoff from the 25-year, 24-hour storm. For facilities with a drainage area, the storage structure must also have capacity to contain precipitation and runoff from the drainage area during the storage period. Adequate manure storage volume shall be provided and maintained to prevent the necessity of land applying manure on frozen and/or snow covered ground or periods of soil saturation. No later than September 15 of each year, the CAFO shall evaluate the storage capacity in their manure storage or treatment facilities and determine what steps are needed to avoid the need to land apply manure on frozen or snow covered fields for the upcoming winter. The operating record for the facility shall include documentation of the storage level as well as what was considered in this evaluation, and what actions were taken to avoid the need for land application of manure on frozen or snow covered ground. Failure to perform the evaluation or failure to take action if the evaluation indicates that action was necessary to avoid land application on frozen or snow covered ground shall be considered a violation of the permit.

2. No Discharge for Production Areas

Effluent Limitations for the Production Area

§412.31(a) Except as provided in paragraphs (a)(1) through (a)(2) of this section, there must be no discharge of manure, litter, or process wastewater pollutants into waters of the U.S. from the production area.

Also **§412.32(a), §412.33(a), §412.43(a), §412.44(a)**, and **§412.45(a)**.

The CAFO effluent guidelines require all Large dairy cow, cattle, veal calf, swine, chicken, and turkey CAFOs to meet a no discharge standard. ***This means there can be no addition of any pollutant or combination of pollutants to waters of the U.S. under any climatic circumstances*** (see the exception below). The no discharge requirement applies to the entire production area, including all manure, litter, and process wastewater whether stored close to or far away from the animal confinement area. Process wastewater includes, among other things, any water which comes into contact with any raw materials, products, or byproducts (see 40 CFR 412.2(d)). Dilution of manure or wastes does not exempt the waste stream from the no discharge requirement.

Even a well-managed facility may experience unusual situations with the potential to cause a discharge beyond the operator's control. Consistent with existing provisions included in the NPDES regulations at 40 CFR 122.41, upset and bypass provisions are included as standard conditions in all NPDES permits to address the potential for unforeseen circumstances. An upset is an unintentional noncompliance event occurring for reasons beyond the reasonable control of the permittee. The upset provision in the NPDES permit operates as an affirmative defense to prosecution for violation of technology-based effluent limitations, provided certain specified criteria are met. For example, flood damage or other severe weather damage to containment structures that cannot reasonably be avoided or controlled by the permittee could be a basis for an affirmative defense for an upset. A bypass, on the other hand, is an act of intentional noncompliance during which waste treatment facilities are circumvented under certain specified circumstances, including emergency situations. The bypass provision authorizes bypassing to prevent loss of life, personal injury, or severe property damage where there are no feasible alternatives to the bypass and where the permitting authority is properly notified. See 40 CFR 122.41(m)[2]. See the *Permit Writers Guide* and 40 CFR 122.41(n) for more information. In other words, even though the regulations prohibit discharges from the production area, a permitted CAFO can claim an upset/bypass defense for events that are beyond its reasonable control, including extreme weather events as well as other uncontrollable or unforeseen conditions.

The no discharge requirement in the CAFO rules does not apply to discharges of non-contact storm water. Requirements applicable to storm water discharges are specified at 40 CFR 122.26(b)(14). EPA generally defines "storm water associated with industrial activity" to include storm water discharges from facilities subject to effluent guidelines or New Source Performance Standards for storm water. Examples of such areas include immediate access roads and rail lines used or traveled by carriers of raw materials, manufactured products, waste material, or by-products used or created by the facility; refuse sites; sites used for the storage and maintenance of material handling equipment; and shipping and receiving areas. Additional permit conditions that apply to storm water discharges are beyond the scope of this document. However, CAFOs are encouraged to follow good housekeeping and spill prevention and response procedures at all times.

No Discharge Exception

If a CAFO chooses to implement minimum design standards for containment (discussed in Section A.1 of this chapter), the CAFO may be allowed a discharge. Production area discharges from Large CAFOs are permitted only when they consist of weather related overflows, and are permitted only in those cases where a storage structure has been designed, constructed, operated, and maintained in accordance with the effluent guidelines requirements. Only the overflow is a legitimate discharge under the effluent guidelines. Consequently, an operation cannot “pull the plug” and empty the runoff control systems simply because an overflow is occurring. Proper operation and maintenance of storage structures is discussed in the following section.

[2] One important distinction here is a facility with a “no potential to discharge” determination does not have a permit, and is, therefore, not entitled to the upset and bypass provisions.

B. Proper Operation and Maintenance

> **Proper Operation and Maintenance**
>
> Proper operation and maintenance (O&M) is a standard condition in all NPDES permits (40 CFR 122.41(e)). Proper O&M of storage structures includes activities such as periodic solids removal to maintain storage capacity, maintenance of berms and sidewalls, prompt repair of any deficiencies, and appropriate dewatering activities. CAFOs must actively manage storage structures to maintain the appropriate capacity, including the capacity to contain the runoff and precipitation from the 25-year, 24-hour storm event.

Overflows from production areas are only in compliance with 40 CFR Part 412 if the facility's storage structure is properly designed, constructed, operated, and maintained. CAFOs that do not actively maintain the capacity of the storage structure, are not entitled to this overflow. For example, a CAFO that starts dewatering only when the storage structure is completely full (such that additional capacity to accommodate a 25-year, 24-hour rainfall event does not exist) is not deemed "properly operated" and any related overflows would be in violation of the permit.

The permissible overflow should be limited to the amount necessary to maintain the structural integrity of the storage structure. To reiterate, the overflow allowance does not allow CAFOs to use permissible overflows during heavy rainfalls as an opportunity to pump additional process wastewater out of the liquid storage structure.

For an overflow to be allowed, the effluent guidelines also require that the production area is operated in accordance with additional practice measures and record keeping requirements in the effluent guidelines at 40 CFR 412.31(a)(1)(ii)) in addition to the more general operation and maintenance requirements in 122.41. All production areas must be operated and maintained to prevent the discharge of pollutants into waters of the U.S. This includes, but is not limited to, activities such as:

1.- Conducting frequent inspections of storage structures to confirm they have adequate storage capacity as specified in 40 CFR 412;

2.- Removing solids from storage structures as needed to maintain the design storage capacity;

3.- Maintaining storage capacity for the design storm event (25-year, 24-hour storm event for existing CAFOs and 100-year, 24-hour storm event for new CAFOs);

4.- Establishing controls to prevent burrowing animals and plants from eroding storage structure berms, embankments, liners, and sidewalls;

5.- Stabilizing berms and embankments with vegetation, rock, or other materials to prevent erosion;

6.- Checking to ensure that all inlets and outlets to the storage structure are not blocked by debris or ice; and

7.- Visually inspecting the perimeter of any storage structure to ensure any runoff or process wastewater is contained.

The following sections describe recommendations for the proper design, construction, operation, and maintenance of storage structures. When designing new or expanded storage structures, CAFOs should consider any potential air or ground water impacts. CAFOs should also properly handle non-contact storm water, as described in Section A.2 of this chapter. Section E of this chapter discusses additional voluntary controls that can be used to minimize volatilization and leaching of pollutants.

1. Liquid Storage Structures

The minimum design volume for liquid storage structures should be based on the maximum length of time between emptying or dewatering events (i.e., the minimum storage period); see Example 2-2F. The appropriate frequency of emptying events may vary for each CAFO based on factors such as:

•- Storage structure size (i.e., if it contains more than the minimum required storage capacity);

• Hydraulic limitations of a land application site;

• Typical rainfall for the area;

• Nutrient concentrations in the stored liquid;

•- Allowable timing of land application such as winter applications as specified in a Nutrient Management Plan; and

• Extent to which the liquid in the storage structure is used for irrigation water.

Example 2-2. Examples of Site-Specific Determination of Adequate Storage (Continued)

Example F: Capacity for the winter season
A swine operation is located in a northern state that prohibits land application of manure to frozen, snow-covered, or saturated ground. For the CAFO's location, the winter season lasts about 150 days. The CAFO constructs 150 days of storage (length of the winter season). The CAFO plans to land apply manure and process wastewater every six months (before and after the main cropping season).

Does the CAFO meet the adequate storage requirements?

No, the CAFO does not have adequate storage. The CAFO sized their storage to hold manure, litter, and process wastewater generated during the 150-day winter season; however, the CAFO's land application schedule (every six months, or approximately 180 days) requires a larger storage capacity. To ensure adequate storage, this CAFO should take into account the number of days between land application and the start of the 150-day winter season; when that number of days is added to the 150-day "no application" period in the winter, the amount of necessary capacity might in fact exceed 180 days.

In most cases, storage is an integral part of overall nutrient management. This minimum storage period provides the capacity to store all manure and process wastewater plus rainfall events until optimal land application (i.e., the nutrients are needed by the crops, the soil can assimilate it, or there is little to no risk for runoff). States will generally establish this period through their technical standards for land application, as required by the regulations (see Chapter 6 of this manual for more information on technical standards).

The CAFO rules do not specify exactly how this site-specific total design volume should be calculated, but EPA provided clarification on how this should be done in the preamble as follows. The total design volume for a liquid storage structure must include an allowance for each of the following:

- The volume of manure, process wastewater, and other wastes accumulated during the storage period;
- The volume of "normal" precipitation (i.e., precipitation from other than the design rainfall event) minus evaporation on the storage structure surface area during the entire storage period;
- The volume of runoff from the facility's drainage area during "normal" rainfall events during the storage period;
- The volume of precipitation from the 25-year, 24-hour rainfall event on the storage structure surface area;
- The volume of runoff from the facility's drainage area from the 25-year, 24-hour rainfall event;

- In the case of anaerobic waste treatment lagoons, the minimum treatment volume;
- The volume of solids remaining in a storage structure after liquids are removed; and
- Necessary freeboard.

Additional storage may also be required to meet management goals or other regulatory requirements.

The volume of "normal" precipitation for the storage period should reflect all precipitation associated with the rainy season at times when dewatering is not possible. (see the text box on chronic rainfalls). Frequent overflows are a potential indicator that a CAFO is not meeting its permit obligations to ensure adequate storage and to properly manage the facility.

Chronic Rainfalls

A storage structure should have capacity for the maximum length of time anticipated between emptying events. This storage volume should also accommodate all wastes, precipitation, and runoff for this period of time. Therefore, properly designed systems should already account for the "rainy season" or the non-growing season typical of the CAFO's location.

When a series of rainfall events (such as chronic rainfalls) precludes dewatering, the remaining capacity of the storage structure is reduced. Even so, it is highly unlikely that any given series of storms would result in an overflow, unless the series of storms occurs so close to the end of the design storage period that the storage structure is already filled close to capacity. When dewatering is not possible, a rainfall event of any size, both smaller and larger than the 25-year, 24-hour storm event, could result in an overflow that is in compliance with effluent limitations based on 40 CFR Part 412. CAFOs that do not actively maintain the capacity of the storage structure, such as CAFOs with minimal capacity, or CAFOs that start dewatering only when the storage structure is completely full, are not entitled to this overflow allowance.

The volume needed for storing solids varies by the presence and efficiency of solids separation equipment or processes, and the extent to which the liquid storage structure provides treatment. The total volume needed for solids accumulation also depends on the length of time between solids removal. Facilities that completely agitate a manure pit prior to pumping are likely to need less solids storage volume than facilities that only draw irrigation water from the top of the liquid storage structure. Facilities that do not intend to remove solids for many years at a time will need solids storage volume for that entire period of time. Each CAFO must identify the site-specific design basis in their records and maintain a copy of these records on site; see Section D of this chapter for more information.

Freeboard Definition

The term *freeboard* is not defined in the CAFO rules, and is not specified by EPA. EPA encourages the use of NRCS and American Society of Agricultural Engineers (ASAE) standards that use freeboard as a safety feature designed to protect the structural integrity of a liquid storage structure. Generally, freeboard is the distance from the top of the maximum design storage volume to the top of the storage structure.

The ASAE standard entitled *Design of Anaerobic Lagoons for Animal Waste Management (ASAE EP403.3 Dec 98)* recommends that freeboard be 0.3 meters (1 ft) for lagoons without a drainage area and 0.6 meters (2 ft) for lagoons with a drainage area. States may have additional requirements or alternate definitions of freeboard, but generally permitting authorities should consider the use of freeboard for additional storage not to be proper operation and maintenance. A spillway is often constructed at this level to prevent use of the freeboard area as additional storage capacity. Freeboard can vary from one foot in cases where inflow to the structure storage is controlled (e.g., influent is pumped into storage structure) to two feet when the inflow is not controlled (e.g., runoff from an uncovered animal confinement area flows freely into the storage structure).

The cross section in Figure 2-2 illustrates the design volume requirements for an anaerobic treatment lagoon used as the storage structure in a production area. Additional storage volumes may be required to meet management goals or other regulatory requirements established by the permitting authority. Examples of additional storage volumes include storage for when fields are dormant or no cover crop exists; extra capacity for those climates where the rainy season is exceptionally heavy or erratic; and additional storage for where land application to frozen or snow-covered ground is prohibited. CAFOs should check with their permitting authority for additional design requirements for storage structures at a CAFO production area.

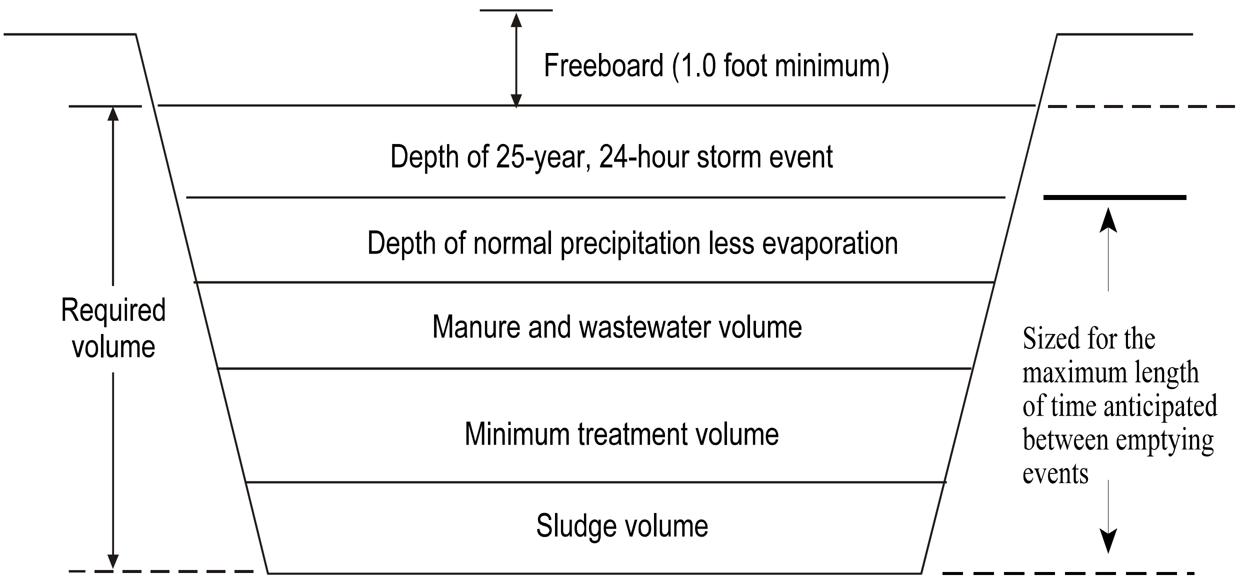


Figure 2-2. Cross Section of Properly Designed Lagoon

Treatment Lagoons

A lagoon is one type of liquid storage structure (a runoff pond is another example). Lagoons are different from most other liquid storage facilities in that a lagoon is designed to biologically treat high pollutant load wastes such as manure and wastewater. In a lagoon, the manure becomes partially liquefied and stabilized by bacterial action before eventual land application. In contrast, a waste storage pond or runoff pond is not designed to provide treatment, and thus is typically smaller than a lagoon. Anaerobic lagoons operate without any considerable oxygen present, and are considerably smaller than aerobic lagoons. Aerobic lagoons are designed to provide a higher degree of treatment with less odor production, but require significantly more surface area and/or mechanical means for increasing the oxygen content in the lagoon. Anaerobic lagoons also decompose more organic matter per unit volume than aerobic ones.

Lagoon capacity should be based on the maximum daily loading considering all waste streams to be treated by the lagoon. Most agricultural lagoons are anaerobic, which have a minimum treatment volume based on the volatile solids (VS) loading. Additional capacity may be necessary to accommodate the proper utilization of treated manure on crops. Usually this results in a minimum treatment period of several months; see the text box for more information on treatment lagoon design.

Lagoons can be designed as single-stage or multiple-stage lagoons. Lagoons may also be used in combination with a solids separator, which is a typical arrangement for many dairy CAFOs. CAFOs should consider multiple-stage lagoons where the first cell can be operated as a constant volume treatment cell, and the subsequent cells can be used for polishing and storage. Multiple stage lagoons do not require a significantly greater total volume than single-stage systems. This approach results in a higher quality lagoon effluent, and may be helpful where the CAFO has a limited land application area or a reduced need for manure nutrients on some fields. Many CAFOs recycle the treated effluent from a treatment lagoon for flushing or cleaning. CAFOs should consider the feasibility of multiple stage lagoons when designing or expanding a lagoon system.

When anaerobic lagoons biologically treat manure, nondegradable solids settle to the bottom as sludge. In addition, COD (chemical oxygen demand), VS (volatile solids), and P (phosphorus) accumulate in the sludge. Periodic removal of accumulated solids and sludge is necessary to maintain the treatment capacity (or minimum treatment volume) of the lagoon. The concentration of solids and nutrients (particularly phosphorus and potassium) in the solids may assist some CAFOs with an excess of nutrients or shortage of cropland, as this allows CAFO to transport the excess nutrients as a concentrated sludge much more economically than diluted wastewater. Solids accumulation beyond the design sludge volume is a potential indicator of an improperly operated and maintained lagoon, and can result from the expansion of the CAFO without a corresponding modification to the design of the treatment lagoon or failure to clean out the lagoon at specified intervals. Particularly malodorous lagoons may also be an indicator of overloaded or improperly maintained lagoons.

Treatment Lagoon Design

One reference for design of an anaerobic lagoon is the ANSI/ASAE standard EP403.3 entitled “Design of Anaerobic Lagoons for Animal Waste Management.” ASAE’s standard on the design of anaerobic lagoons states that the lagoon depth should provide for a 6.6 foot minimum depth when the lagoon is filled to its treatment volume elevation which should be at least 1 foot above the highest ground water table elevation. ASAE also recommends making the lagoon as deep as practical to reduce surface area and convection heat loss, enhance internal mixing, reduce odor emissions, promote anaerobic conditions, minimize shoreline weed growth problems, and reduce mosquito production. This standard also provides equations for calculating the total lagoon volume and a listing of recommended maximum loading rates for anaerobic lagoons for animal waste in mass of volatile solids per day per unit of lagoon volume. The treatment volume is sized on the basis of waste load (volatile solids or VS) added per unit of volume and climatic region. Maximum lagoon loading rates are usually based on average monthly temperature and corresponding biological activity. If odors are of concern, consideration is also given to reducing the VS loading.

The NRCS Standard Practice 359 *Waste Treatment Lagoon*, provides information on minimum top widths, operating levels, embankment elevations, and considerations for minimizing the potential of lagoon liner seepage.

Other frequently used references are NRCS’ “Agricultural Waste Management Field Handbook”, Part 651, National Engineering Handbook, ASAE Engineering Practice standard ASAE EP393.3 “Manure Storages”, and Midwest Plan Service publication MWPS-18.

In addition to solids management and careful attention to lagoon loading rates, other important operation and maintenance measures include:

- Proper start-up procedures whenever lagoons are modified or first operated;
- Protection of interior slopes with vegetation, mulch, stone, or other means to prevent erosion of the liner;
- Trimming of vegetation on embankments to prevent roots from digging through the liner;
- Inspection of embankments for animals, insects, or worms that may dig through the liner;
- Lagoons should be fenced and warning signs posted to ensure safety;
- Operation at minimum operating liquid level at the beginning of the design storage period, especially late fall and early winter;
- Permanent depth markers showing maximum liquid levels and the lowest pump-down level; and
- Periodic visual inspections.

See section 3 of this chapter for more information on visual inspections.

Evaporative Lagoons

Some CAFOs send manure and process wastewater to an evaporative lagoon. This is a shallow, uncovered lagoon which has a large enough surface area that much of the liquid evaporates off the lagoon through exposure to sun and wind. The advantage of this is that CAFOs in arid climates may not have to be concerned with land applying effluent. In many cases, the amount of wastewater produced is generally small enough when compared to evaporation that the lagoon would pose little to no risk of overflow and, therefore, would not require any pumping during most years. The level of the surface area increases during the winter months when evaporation rates decrease. However, such lagoons have generally been designed with more than enough storage to ensure they do not have to be pumped during the winter.

The evaporative lagoon, by design, allows for the water to evaporate while the solids and salts remaining in the lagoon accumulate as a concentrated sludge. At some point, the solids that accumulate in the evaporative lagoon will require removal. When removed, any land application of these solids to crop land must be applied at appropriate agronomic rates, as described elsewhere in this guidance document. The accumulated solids are high in organic matter, but the nutrients will consist of concentrated phosphorus and little to no nitrogen. Thus the major disadvantage of evaporative lagoons is that evaporation causes most of the nitrogen to be lost to the air (primarily volatilized as ammonia).

Additional Measures

§412.37(a)(2) Depth Marker. All open surface liquid impoundments must have a depth marker which clearly indicates the minimum capacity necessary to contain the runoff and direct precipitation of the 25-year, 24-hour rainfall event, or, in the case of new sources subject to the requirements in §412.46 of this part, the runoff and direct precipitation from a 100-year, 24-hour rainfall event.

Depth Markers

A depth marker is a tool that allows CAFOs to manage the liquid level in an impoundment to ensure that the impoundment has adequate capacity to contain direct precipitation and runoff from the design rainfall event. Without a depth marker, impoundments may fill to a level above their capacity, leading to overflows. The CAFO rules require that all open surface liquid impoundments in a production area have a permanent depth marker. The depth marker must indicate the minimum capacity needed for the runoff and direct precipitation from a 25-year, 24-hour rainfall event. In the case of closed or covered liquid impoundments, depth markers allow CAFOs to maintain levels in those impoundments so that accidental discharges do not occur. Only open surface liquid impoundments are required to have a depth marker, but level indicators are useful management tools for all types of liquid impoundments.

It is also a good practice to indicate the maximum drawdown level on the depth marker in a treatment lagoon to ensure that the lagoon has the volume needed for biological treatment and capacity for all solids accumulating between solids removal events. Figure 2-3 provides an illustration of a open surface liquid impoundment with a depth marker.

CAFOs may use remote sensors to measure the liquid level in an impoundment. Sensors can be programmed to trigger an alarm when the liquid level changes rapidly or when the liquid reaches a critical level. The sensor can transmit to a wireless receiver to alert the CAFO about an impending problem. One advantage of a remote sensor is that it can provide CAFOs with a real-time warning that the impoundment is in danger of overflowing. CAFOs may use remote sensors to track liquid levels to supplement the weekly required inspections of all manure and process wastewater structures (required inspections and associated records are described later in this chapter).

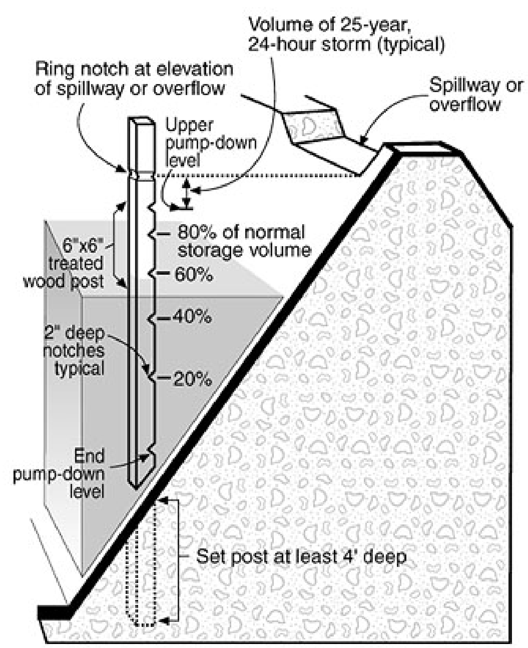


Figure 2-3. Schematic of Lagoon Depth Marker

Source: Earthern Pits (Basins) for Liquid Livestock Manure (November 2000)

Even though remote sensors are more expensive, the price may be offset by the additional assurance they can provide in preventing accidental discharges and circumventing catastrophic failures.

Divert Clean Water From Production Areas

Additional Conditions Applicable to CAFOs

§122.42(e)(1)(iii) Ensure that clean water is diverted, as appropriate, from the production area.

In some cases, CAFOs may choose to collect clean water, roof water, storm water, and other water streams that are not otherwise defined as process wastewater and contain them in liquid storage structures (e.g., runoff ponds). CAFOs located in extremely arid climates may decide to collect any and all clean water for irrigation. Other CAFOs use the additional water to aid in land application of manure (e.g., additional water partially dilutes the manure to aid in pumping through irrigation or land spreading equipment). CAFOs choosing to collect this water and store it commingled at the production area along with their process wastewater must now handle all of the water as process wastewater. CAFOs must account for these additional volumes in the design, construction, and operation of their storage facilities. Reducing the total volume of process wastewater generated in the production area benefits an operation by reducing the volume of wastewater that has to be stored, treated, land applied, and disposed of. Smaller volumes of process wastewater often translates to smaller storage structures, which has many positive environmental and economic advantages. In most cases, it is both appropriate and desirable to divert this clean water from the production area.

CAFOs not including additional volume in the storage structures for “clean” storm water runoff (e.g., rain falling on roofs of buildings and runoff from adjacent lands) must prevent clean water from reaching the production area. Clean water can be diverted from the production area by using earthen perimeter controls and roof runoff management techniques.

Earthen perimeter controls usually consist of a berm, dike, or channel constructed along the perimeter of a site. Simply defined, an earthen perimeter control is a ridge of compacted soil, often accompanied by a ditch or swale with a vegetated lining, located at the top or base of a sloping area. When properly placed and maintained, earthen perimeter controls are effective in controlling the velocity and direction of storm water runoff. Used by themselves they do not have any ability to remove pollutants and, thus, must be used in combination with an appropriate sediment or waste trapping device. Roof runoff management techniques such as gutters and downspouts direct rainfall from roofs away from production areas. Roof gutters are illustrated in the picture on the right.

Both earthen perimeter controls and roof management devices must be maintained to remain effective. For example, vegetation in a channel (e.g., ditch or swale) that accompanies an earthen perimeter control should be mowed periodically to prevent the vegetation from decreasing the channel velocity, which could cause the channel to overflow. In addition, the original height of a dike in an earthen perimeter control should be maintained; any decrease in height due to settling of manure, other solids, or erosion should be corrected. Roof management devices such as gutters and downspouts must be cleaned and inspected regularly to prevent clogging and to ensure their effectiveness.

2. Solid Storage Structures

Examples of solid storage structures include storage areas for solid manure such as the lower level of high-rise poultry houses, sheds for poultry litter, pits, stockpiles, mounds in dry lots, compost piles, and pads. CAFOs should manage all runoff from these areas. Permit authorities may also require CAFOs to manage any seepage to groundwater from these areas. The floor of solid manure storage areas should be constructed of compacted clay, concrete, or other material designed to minimize the movement of wastes beneath the storage area. The floor should be sloped toward a collection area or sump so that any runoff or liquid can be collected and transferred to a liquid manure storage area or treatment system. Also, CAFOs should consider storing stockpiles of solid manure under a roof or cover them to exclude precipitation whenever possible. For example, poultry litter stockpiled in a field for long term storage should be covered to reduce or eliminate the need to collect all runoff from the litter pile.

3. Visual Inspections

Visual inspections help ensure proper operation and maintenance of the production area. Most discharges can be prevented through early identification of potential equipment and system failures. The CAFO rules require periodic inspections of the production area. CAFOs should look for the following common problems during these inspections:

- Seepage through waste storage embankments;
- Erosion of waste storage embankments;
- Vegetation growing in storage areas;

> **Visual Inspections**
>
> **§412.37(a)(1)** There must be routine visual inspections of the CAFO production area. At a minimum, the following must be visually inspected:
> (i) Weekly inspections of all storm water diversion devices, runoff diversion structures, and devices channelling contaminated storm water to the wastewater and manure storage and containment structure;
> (ii) Daily inspection of water lines, including drinking water or cooling water lines;
> (iii) Weekly inspections of the manure, litter, and process wastewater impoundments; the inspection will note the level in liquid impoundments as indicated by the depth marker.

- Animals accessing storage areas;
- Levels approaching freeboard;
- Improperly functioning rain gauges; and
- Improperly functioning irrigation and land application equipment.

CAFOs must inspect the water lines at the CAFO daily, including drinking water and cooling water lines, to ensure they are not leaking. Leaks from these lines can increase the volume of wastewater that has to be stored in the production area storage structures and could result in the discharge of pollutants from the storage structure. Leaks from these lines can also cause what is otherwise a “dry” manure management system to discharge. Leaking water lines also can increase water and electricity bills. Many facilities now use automatic shut-off valves to detect pressure changes in the water lines.

Weekly inspections are required for all storm water diversion devices, runoff diversion structures, and devices that channel contaminated storm water to the wastewater and manure storage and containment structures. These inspections help ensure that the devices (e.g., roof gutters) and structures are free from debris and remain in good working condition.

Weekly inspections are required for manure, litter, and process wastewater impoundments. For surface and liquid impoundments, CAFOs should inspect berms for signs of structural weakness (e.g., seepage and wind or water erosion). CAFOs must note the depth of manure, litter, and process wastewater in any open surface liquid impoundment as indicated by the depth marker during the weekly inspections.

CAFOs must correct all deficiencies found during the daily and weekly inspections as soon as possible (see 40 CFR 412.37(a)(3)). CAFOs must keep records to document that the corrective actions were taken, and the records must indicate any factors that prevented immediate corrective actions from being taken where deficiencies are not corrected within 30 days (see 40 CFR 412.37(b)). Appendix B contains a sample checklist for the daily and weekly inspections required for a Large CAFO production area. CAFOs may consider using this checklist to design their production area inspection routine.

C. Mortalities, Direct Contact, and Chemical Disposal

To prevent contamination of the nation's waters, the regulations require CAFOs to ensure proper management of dead animals to ensure that they are not disposed of in any liquid manure, storm water, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities to prevent the direct contact of confined animals waters of the U.S. The regulations also require CAFOs to ensure that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, storm water, or process wastewater storage or treatment system unless the system is specifically designed to treat such chemicals and other contaminants. CAFOs must properly handle animal mortalities, prevent animals from direct contact with surface water, and properly dispose of chemicals. These regulatory requirements are discussed below.

> **Mortality Handling**
>
> **§122.42(e)(1)(ii)** Ensure proper management of mortalities (i.e., dead animals) to ensure that they are not disposed of in a liquid manure, storm water, or process wastewater storage or treatment system that is not specifically designed to treat animal mortalities.
>
> **§412.37(a)(4)** Mortalities must not be disposed of in any liquid manure or process wastewater handling system, and must be handled in such a way as to prevent the discharge of pollutants to surface waters, unless alternative technologies pursuant to §412.31(a)(2) and approved by the Director are designed to handle mortalities.

1. Management of Animal Mortalities

Despite improved health and production practices, intermittent mortality occurs at animal feeding operations. In some cases, a CAFO may need to handle catastrophic mortality. The CAFO should ensure the proper handling and disposal of dead animals to ensure biosecurity, to avoid creating nuisance conditions, and to manage any pathogens decaying carcasses produce. All CAFOs must not dispose of dead animals in a liquid manure, storm water, or process wastewater storage or treatment system unless the system is designed specifically to treat mortalities (see 40 CFR 122.42(e)(1)(ii)). In addition, Large CAFOs subject to the effluent guidelines may not dispose of mortalities in any liquid manure or process wastewater system unless alternative technologies pursuant to the *Voluntary Alternative Performance Standards* have been approved by the Director (see 40 CFR 412.37(a)(4)). For example, homogenization of mortalities may be an appropriate method of treatment, but subsequent disposal in a runoff pond is not.

Photo by USDA NRCS

Mortality disposal methods include burial, composting, incineration, and rendering. CAFOs should determine the most appropriate method based on the type(s) of animal(s) maintained at the operation, state and local laws, and storage capabilities. For example, many poultry producers previously used fabricated pits for burying dead birds, but due to potential contamination of groundwater from pollutants leaching from these pits, many states now prohibit burial. Currently, many poultry producers compost dead birds between layers of litter and straw. In many states, burial is now allowed only during instances of catastrophic mortality.

Due to the size of cattle carcasses, frequency of autopsies, and economics of mortality handling, most beef and dairy cow producers use rendering as their primary method of mortality disposal. Swine producers bury, incinerate, render, and compost their dead animals. During the last several years, however, more swine producers have switched from burial to composting.

CAFOs should consider incorporating a mortality management strategy into the Nutrient Management Plan that includes the following five components identified in ANSI GELPP 005-2002 *Mortality Management*:

- A schedule for collecting, storing, and disposing of carcasses;
- A description of how mortalities will be stored on site prior to disposal;
- A description of the final method for mortality disposals;
- A contingency plan that addresses reasonable foreseeable issues such as mass mortality due to mechanical failures or weather, loss of contract transporter for rendering, and euthanization due to disease outbreaks; and
- Records of mortality disposal (e.g., date, numbers of animal, final disposition).

To prevent the transmission of possible diseases, CAFOs should try to remove all carcasses from the animal living areas within 24 hours, minimize insect and rodent populations in the mortality storage areas, and use mortality storage areas with impermeable bases. Below are specific recommendations for each mortality disposal method as described in the ANSI *Mortality Management* standard:

- Off-Site Rendering: The CAFO's contingency plan should include at least one alternative carcass hauler and, if practical, one alternative rendering facility or other facility capable of properly disposing of carcasses.
- Composting: CAFOs must ensure that clean water is diverted from the composting areas. The composting facility should be constructed with an impermeable base and roofed, carcasses should be prepared properly for composting, carcasses should be placed in the compost structure properly, and all carcasses should be covered completely by the compost amendment.
- Burial: CAFOs should ensure that the burial locations are not in sensitive areas (e.g., floodplains, areas with shallow water tables, sandy soils, near surface water, or near groundwater wells), carcasses are prepared properly, and carcasses are covered properly.

- Incineration: CAFOs should ensure that the incinerator is operational, the capacity of the incinerator is not exceeded, and the incinerator is maintained and secured properly.

Additional information on the proper management of animal mortalities can be found in "NRCS Practice Standard Animal Mortality Facility-316." This standard provides information for using freezer units, disposal and burial pits, incinerators, and considerations for planning normal and catastrophic animal mortality management.

2. Direct Contact of Animals With Surface Water

> **Additional Conditions Applicable to CAFOs**
>
> **§122.42(e)(1)(iv)** Prevent direct contact of confined animals with waters of the United States.

To help ensure that wastes generated by animals confined in a production area do not contaminate waters of the U.S., CAFOs must prevent direct contact by the animals with such waters. Direct contact means an animal is standing in a water body or walks through it. For example, if a cow walks through a stream in a production area, there is direct contact with the stream by the cow. Fences are a common method of preventing animals from contacting surface water bodies. CAFOs that use fencing in the production area to control animals' access should check fence lines regularly and repair any damaged sections as soon as they are identified. CAFOs should also provide an alternative water source for the animals to discourage walking through streams.


Photo by USDA NRCS

3. Disposal of Chemicals

> **Additional Conditions Applicable to CAFOs**
>
> **§122.42(e)(1)(v)** Ensure that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or storm water storage or treatment system unless specifically designed to treat such chemicals and other contaminants.

CAFOs must not dispose of chemicals and other contaminants handled on-site into a manure, litter, process wastewater, or storm water storage or treatment system unless the system is specifically designed to treat these chemicals and other contaminants. If the storm water storage or treatment system is not designed to handle chemicals and other contaminants, disposing of the materials in those systems could cause the treatment system to fail, and could discharge pollutants. For example, expired or wasted antibiotics must not be disposed of in a confinement building pit or flushed out of hospital pens into the liquid manure storage areas. Biological treatment systems such as lagoons and digesters are sensitive to certain chemical loads, and these treatment systems could fail.

CAFOs should minimize the use of potentially harmful chemicals/contaminants and ensure these products are used and disposed of properly. For example, it may not be consistent with chemical labels to dispose of rinse water from spent chemical containers in the storage structure. The permit may specify additional restrictions and controls for these trace chemicals where necessary. To properly dispose of any chemical, operators should follow instructions provided on labels or documentation from the supplier.

D. Records

CAFOs must keep records to document that the design, operation, and maintenance requirements for a CAFO production area described above are met. These records must be kept for a minimum period of five years after they are created. See 40 CFR 122.42(e)(1)(ix) and (e)(2). CAFOs must make these records available to the Director or his or her designee.

The CAFO must keep the following production area records:

- Specific records that will be maintained to document the implementation and management of the minimum elements listed in §122.42(e), including: ensure adequate storage; ensure proper management of mortalities; clean water diversions; prevent direct contact of animals; ensure proper chemical disposal.

- Documentation of all required visual inspections (see Section B.3 of this chapter). Note that though visual inspections of water lines are required daily, the record may consist of a signed weekly log assuring the inspections were conducted. See the *Producers Guide* for more information.

- Weekly records of the depth of the manure and process wastewater in the liquid impoundment as indicated by the depth marker. See Section B.1 of this chapter.

- Records documenting any actions taken to correct observed deficiencies.

- Explanation of the factors preventing immediate correction of deficiencies, for deficiencies not corrected within 30 days.

- Records of mortality management and practices used by the CAFO to meet the requirements for mortalities handling and disposal.

Recordkeeping

§122.42(e)(2) The permittee must create, maintain for five years, and make available to the Director, upon request, the following records...

§122.42(e)(3) ...Large CAFOs must retain for five years records of the date, recipient name and address, and approximate amount of manure, litter, or process wastewater transferred to another person.

§412.37(b) Each CAFO must maintain on-site for a period of five years from the date they are created a complete copy of the information required by 40 CFR 122.21(i)(1) and 40 CFR 122.42.(e)(1)(ix) and the records specified in paragraphs (b)(1) through (b)(6) of this section. The CAFO must make these records available to the Director and, in an authorized State, the Regional Administrator, or his or her designee, for review upon request.

- Records documenting current design of any manure or litter storage structures, including volume for solids accumulation, design treatment volume, total design volume, and approximate number of days of storage capacity. The documentation should also reflect any significant changes to these systems, such as changes to the waste handling system due to expanded or reduced number of animals.

- Records of the date, time, and estimated volume of any overflow.

Appendix C contains a sample checklist for the records that must be kept for a production area at a Large CAFO.

E. Additional Voluntary Controls

In addition to the requirements described above, there are many other controls that CAFOs can implement to increase the efficiency and environmental protection of storage structures. CAFOs should consult their state and local regulatory authorities to make sure these voluntary controls are not already required or prohibited. Examples of voluntary controls include groundwater protection controls and lagoon covers. They are discussed below.

1. Groundwater Protection Controls

Various controls are available to reduce the potential for the discharge of pollutants to the groundwater. These include, but are not limited to, storage structure liners and groundwater monitoring.

Liners prevent pollutants from leaching into the groundwater from the bottom and sides of a storage structure. They can be made of natural (e.g., heavy clay) or synthetic (e.g., plastic or rubber) materials. To be effective, liners must be inspected periodically to ensure they are not leaking. CAFOs should check with their permitting authority for any state requirements concerning lagoon liners. For example, California currently requires waste management units at CAFOs to be lined with or underlined with soils containing at least 10 percent clay and not more than 10 percent gravel or artificial materials of equivalent impermeability; Idaho currently requires a 2-foot compacted layer of heavy soil, concrete or asphalt, or synthetic membrane liners. Other states may also require additional monitoring or controls to protect groundwater (and drinking water) resources.

Groundwater can be monitored periodically to check for pollutant infiltration from a storage structure. Monitoring provides an early warning that there may be a problem with a storage structure and allows early correction of the problem. Monitoring typically requires installing at least one well up-gradient and two to three wells down-gradient from the storage structure. CAFOs should conduct a comprehensive hydrological assessment prior to installing the monitoring wells to ensure that the wells are located properly to detect pollutant releases to the groundwater. Groundwater in some areas is susceptible to seasonal variations of flow and may even change directions of flow. Monitoring of the groundwater beneath a storage structure in a production area is a good idea in areas where there is a strong likelihood of pollutants reaching the groundwater. These situations include areas where the storage structure is located over karst terrain and where the groundwater table is very shallow.

Note that ground water controls may not always be voluntary. On a site-specific basis a NPDES permit may set additional requirements on groundwater discharges where the groundwater has a direct hydrologic connection to surface water. In addition as noted above, a CAFO may be subject to certain ground water controls based on state or local regulatory authorities that are separate from the Clean Water Act NPDES requirements. The CAFO should consult with their state permit authority for more information.

2. Lagoon Covers

Though the CAFO rules do not require the use of lagoon covers, one way to reduce the potential for pollutant discharges from storage lagoons is to install an impermeable cover over the lagoons. Covered lagoon systems have been used successfully in all areas of the country including cold climates. They can now be designed and constructed from materials to resist freezing, high winds, and other extreme weather conditions that may have precluded their use in the past. However, in some instances, covers are an attractive alternative to help reduce the potential for pollutants discharged to surface water bodies by decreasing the volume of storm water that has to be stored. Therefore, CAFOs may be able to design a smaller lagoon to manage all manure and wastewater if it is covered. This will minimize the amount of land that has to be devoted to the impoundment and, in turn, reduces excavation costs. In wet climates, the use of covers can drastically reduce the costs of land application and hauling of manure by eliminating a lot of non-contact water, especially direct precipitation. In many cases the use of a cover can reduce evaporation and the associated loss of nitrogen which in turn may result in significant odor reduction. The additional conserved nitrogen can often be beneficially used by crops. Volatilization of nitrogen is generally viewed as unfavorable, and new treatment technologies specifically include volatilization controls.

Some covered lagoons can also be converted into anaerobic digesters which rely upon a bacterial process to produce methane gas while decomposing organic wastes. The methane generated from the anaerobic digestion can be burned in an engine generator to produce electricity or in a boiler to produce heat. Digesting manure may reduce odor emission, fly production, and may help control some pathogens. CAFOs should be cautioned that digesters still require effluent holding.

Expanding CAFOs in particular may wish to install a constant volume treatment cell in lieu of expanding the existing lagoon. The old lagoon may then be used as the effluent holding cell. As detailed in the ASAE Standard EP403.3 *Design of Anaerobic Lagoons for Animal Waste Management*, CAFOs may use multiple cell lagoons when allowed by local conditions and/or regulations. When operated in a series, the volume of the primary cell should be at least equal to the sum of the treatment volume and sludge accumulation volume. When operated in parallel, each cell's volume should be designed based on the anticipated loadings.

EPA's AgStar Program is a voluntary effort jointly sponsored by EPA, USDA, and the U.S. Department of Energy that encourages the use of methane recovery (biogas) technologies at CAFOs that manage manure as liquids or slurries. EPA's AgStar web site <www.epa.gov/agstar> provides information on anaerobic digestion systems and concepts; a directory identifying appropriate consultants, project developers, energy services, equipment manufacturers and distributors, and commodity organizations; a handbook and software to provide guidance on developing biogas technology at commercial farms; link to USDA standards; and other reports on anaerobic digestion.

Some CAFOs have had success using impermeable covers for odor control and to reduce volatilization. Synthetic impermeable covers include rigid materials (e.g., wood, concrete, fiberglass) or flexible materials (e.g., plastic). CAFOs typically use a floating cover (other types include inflated covers, which are susceptible to high winds, and covers suspended by cables). In addition to synthetic impermeable covers, CAFOs may choose to install biocovers (e.g., straw, cornstalks) or synthetic permeable covers (e.g., geotextile covers for earthen storage, clay ball covers (Leka rock) for concrete storage). When planning the addition of covers, CAFOs should plan for additional maintenance activities, such as removal of excess biocover materials to prevent line plugging and access to the lagoon for pumpout. CAFOs should be cautioned that such controls may be beneficial overall, but will not necessarily reduce potential for overflows.

3. Additional References

A reference CAFOs and permit writers may use in determining whether a facility has adequate storage is EPA's *Cost Methodology for the Final Revisions to the National Pollutant Discharge System Regulation and the Effluent Guidelines for CAFOs* (December 2002)(EPA-821-R-03-004) available at< http://epa.gov/guide/cafo/ >.

CHAPTER 3: PREPARING FOR LAND APPLICATION OF MANURE, LITTER, OR WASTEWATER

As a practical matter, nearly all manure, litter, and process wastewater is land applied. Manure may be treated or processed into "value-added" products to make manure more transportable, uniform, or sellable, but it is still ultimately land applied. Land applied manure can either be applied to a CAFO land application site, or transferred off site to other persons for application to the land. Chapter 4 of this manual describes the requirements for land application of manure to CAFO land application areas. In the case where the manure, litter, or process wastewater is transferred to others, the CAFO must provide the recipient of the manure, litter, or process wastewater with the results of the most current nutrient analysis (i.e., nitrogen and phosphorus) of the material. In addition, CAFOs must document manure transfers with certain records (see Section B below).

> **Manure Transfers**
>
> §122.42(e)(3) Prior to transferring manure, litter, or process wastewater to other persons, Large CAFOs must provide the recipient of the manure, litter or process wastewater with the most current nutrient analysis. The analysis provided must be consistent with the requirements of 40 CFR Part 412. Large CAFOs must retain for five years records of the date, recipient name and address, and approximate amount of manure, litter or process wastewater transferred to another person.

A. Manure Sampling

Knowing the nutrient content of the material provides the CAFO and/or recipient of manure transferred off site with the necessary information to calculate an appropriate application rate for the manure, litter, or process wastewater. Without the nutrient content, including various forms of the nutrients in the manure, an accurate application rate cannot be calculated. Under the requirements of the effluent guideline, CAFOs must sample manure at least once annually for nitrogen and phosphorus content (40 CFR 412.4(c)(3)). Annual nutrient sampling of manure is the minimum frequency on which to base application rates. Many states require sampling more frequently than the minimum annual frequency established by the CAFO rules. Soil factors are also used to determine appropriate application rates; these are addressed in Chapter 4 of this document.

> **Manure and Soil Sampling**
>
> §412.4(c)(3) Manure must be analyzed a minium of once annually for nitrogen and phosphorus content, and soil analyzed a minimum of once every five years for phosphorus content. The results of these analyses are to be used in determining application rates for manure, litter, and other process wastewater.

The CAFO rules do not establish sampling methods and protocols. Soil testing procedures are best suited for particular soil types and climates, and many alternative soil testing methodologies may be used to generate useful predictions of crop response. There are also many different ways to express test results. Analytical results may also vary by testing procedure, and various testing procedures may not be compatible. Analytical results are best correlated to local growing conditions. The currently used protocols and sampling methods vary considerably by geography and climate, and the most appropriate protocols for a given locale are recommended by the local Land Grant University and Extension Offices. CAFOs should use the protocols for the sampling and analysis of manure as established in their state; see Example 3-1.

Example 3-1: Example State Protocols for Laboratory Analysis of Phosphorus

If the soil pH using water pH test is 7.5 or greater, use the Olsen P-test. If the soil pH is less than 7.5, use the Mehlich 3 or Bray P-test.

Commonly Used Testing Protocols for Phosphorus

The Mehlich 1, Mehlich 3, Morgan, and Modified Morgan extractants are predominant for soil tests for phosphorus and the cations in the Northeastern United States. They were designed to dissolve and/or desorb some fraction of the labile P and thus provide an index of the availability of phosphorus to crops over the growing season. Since the chemistry of northeastern soils primarily involves factors affecting the availability of aluminum phosphates, soil tests in the Northeast use a dilute acid solution to dissolve these minerals and extract phosphorus.

When taking representative manure samples, CAFOs should be cautioned that the appropriate sampling and analytical methods may vary by storage system. Sampling the manure as close to the time of application as practical provides the CAFO with a better measure of the nitrogen content of the manure. The most current manure nutrient analysis must be provided to the recipient of the manure transferred off site. Under 40 CFR 412.4(c)(3), the results of the manure nutrient analyses are to be used in determining land application rates. EPA interprets this to mean that CAFOs applying manure to their land application areas must show that application rates are based on the most current manure nutrient analysis (see 40 CFR 412.4(c)(3)); see Chapter 4 of this manual.

What Forms of Nutrients Should Be Tested?

At a minimum, CAFOs should test for total kjedahl nitrogen (TKN), ammonia, total phosphorus, and soluble phosphorus.

Organic forms of nitrogen are converted to inorganic forms of nitrogen during a process called mineralization. The inorganic forms of nitrogen are utilized by plants. Inorganic nitrogen, such as ammonium nitrogen (NH4+), is usually attached to soil particles until used by the plants. In contrast, the nitrate form(NO3-) is highly susceptible to leaching, and can leach before used by the plant.

Adsorbed phosphorus is considered unavailable for plant growth. Erosion and runoff are common ways in which adsorbed phosphorus can transport off site and contaminate surface water. In contrast, highly permeable soils, low pH, and low organic matter allow phosphorus to leach.

The nutrient composition of manure varies widely among farms because of differences in animal species and management, and manure handling and storage practices. Sampling the manure as close to the time of application as practical provides the CAFO with a better measure of the nutrient content (especially nitrogen) of the manure. The only method available for determining the actual nutrient content of manure for a particular operation is laboratory analysis. The rules do not allow CAFOs to use text book values in place of annual manure sampling.

Part of the information CAFOs must provide to the recipient should include the amount of nitrogen (i.e., total kjedahl nitrogen (TKN) and ammonia) and phosphorus (i.e., total phosphorus and soluble phosphorus) in the manure based on the most recent sampling.

EPA recommends CAFOs also provide the percent solids of the manure. Percent solids is used to calculate the dry weight basis of the nutrients and solids in the manure. For example, if a crop requires 10 pounds of nitrogen per acre, to determine how much manure is needed per acre to satisfy the needs of the crop one must calculate the dry weight of nitrogen in the manure; see Example 3-2.

Example 3-2: Calculating the Dry Weight of Nitrogen in Manure

The CAFOs most recent manure sample analysis indicates that the nitrogen content in lb/ton wet weight is 3.3 and the moisture content is 33 percent. To calculate the amount of nitrogen in lb/ton dry weight the CAFO uses the following equation:

$$\text{Concentration N}_{\text{dry basis}} = \text{Concentration N}_{\text{wet basis}} \times (100 - \%\text{ moisture content})$$
$$= 3.3\text{ lb/ton} \times (100 - 33\%)$$
$$= 2.2\text{ lb/ton}$$

B. Records

CAFOs must record specific information when manure, litter, or process wastewater is transferred to other persons for land application. The information that must be recorded includes:

- Date of the transfer;
- The recipient's name and address; and
- Approximate amounts/volume of manure, litter, or process wastewater transferred to the recipient in either tons or gallons.

CAFOs must retain these records for a period of five years after the date of transfer. ANSI's manure utilization standard also recommends that operators execute written manure transfer agreements with all individuals who accept manure for off-site use, outside their control; see example 3-3.

Example 3-3: Sample Manure Utilization Standard

ANSI GELPP 0004-2002, *Manure Utilization* standard recommends that the operator sample and analyze all manure that is managed outside his control. ANSI recommends that sampling be representative of the manure being removed from the production area and if representative sampling is not conducted for each removal of manure, sufficient historical sample data must exist to show that the manure's nutrient and percent total solids content does not vary enough to impact nutrient application planning. At a minimum, ANSI recommends that manure being transferred off site be analyzed for percent total solids, nitrogen content (TKN and ammonia nitrogen), and total phosphorus content.

C. Additional Voluntary Controls

EPA encourages all manure applications by non-CAFOs, including manure land applied off site, to be conducted in accordance with a Nutrient Management Plan such as the type of plan outlined in USDA's Comprehensive Nutrient Management Plan (CNMP). CNMPs are developed in accordance with NRCS conservation planning policy and rely on the planning process and established conservation practice standards. For more information on USDA's CNMP Technical Guidance see: http://www.nrcs.usda.gov/programs/afo/cnmp_guide_600.50.html.

For more general information and updates on CNMP planning, see http://www.cnmpwatch.com/.

CHAPTER 4: OPERATION, MAINTENANCE, AND RECORDKEEPING REQUIREMENTS FOR THE LAND APPLICATION AREA

The requirements discussed in this chapter apply when manure, litter, or process wastewater is applied to the land application area. A *land application area* is the land under the CAFO owner or operator's control, whether it is owned, rented or leased, to which manure, litter, or process wastewater from the production area is or may be applied (40 CFR 122.23(b)(3) and 412.2(e)). Operational control of land includes ownership, rental agreements, leases, and access agreements. This may also include situations where a farmer releases control over the land application area and the CAFO determines when and how much manure is applied to fields not otherwise owned, rented, or leased by the CAFO to another entity.

CAFOs must develop and implement a Nutrient Management Plan to help manage manure, including setting forth a plan for land application. Requirements for developing and implementing a Nutrient Management Plan can be found in 40 CFR 122.42 and 412.4. Among these are the requirements to address the form, source, amount, timing, and method of application of nutrients on each filed to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters. Furthermore, CAFOs should routinely re-evaluate the environmental impacts of the land application of nutrients from animal manure, wastes, commercial fertilizers, biosolids, and any other nutrient sources.

EPA recommends all AFOs (including Large CAFOs) implement the practices discussed in this manual for all land on which manure, litter, or process wastewater is placed to maximize the value of manure and to minimize the potential for runoff of pollutants from the land application area. The following activities are required by the CAFO rules for land application of manure and are discussed in this chapter:

- Identify testing protocols for manure, litter, process wastewater, and soil;
- Establish protocols to land apply manure (including development and implementation of a Nutrient Management Plan);
- Maintain records; and
- Identify appropriate site-specific conservation practices to control runoff.

Section E of this chapter discusses voluntary conservation and pollution prevention strategies.

A. Testing Protocols for Manure, Litter, and Soil

> **Additional Conditions Applicable to Specified Categories of NPDES Permits**
>
> **§122.42(e)(1)(vii)** Identify protocols for appropriate testing of manure, litter, process wastewater, and soil.

To manage manure, litter, and process wastewater properly, applicators must know how much manure is produced and its composition. CAFOs must also know the composition of the soil where manure is to be land applied to calculate an appropriate application rate for the manure. The rate and method of application should consider the soil holding capacity, the nutrient requirements of the crops, slope of the field, nutrients available to the crops from other sources (e.g., nutrients in the soil, nutrients from commercial fertilizer), the physical state of the manure, litter, and process wastewater (e.g., solid, liquid, semi-solid), and the potential for leaching and runoff of any pollutants (including nutrients).

1. Collecting Manure for Land Application

Before samples can be collected that are representative of what will be land applied, and before the CAFO can estimate the total quantity of manure nutrients to be land applied, the CAFO should consider the complete system of manure collection in place at the production area. The ease of collecting all livestock and poultry waste often depends on the amount of freedom given to the animals. If animals are allowed to move freely within a given space, manure will be deposited randomly; animals confined to an area are more likely to defecate in the same places. Waste collection can be automated (e.g., scrape and flush dairy barns) or manual (e.g., removal of waste from a dry lot with a front-end loader). Some CAFOs improve the efficiency of manure collection (i.e., decrease losses) by paving alleys and by installing gutters and slotted floors with mechanical and hydraulic equipment.

CAFOs should implement pollution prevention practices to keep production and collection of unnecessary waste to a minimum. For example, many CAFOs reduce the volume of contaminated runoff from open holding areas by restricting the size of the open holding areas, roofing part of the holding area, and installing gutters and diversions to direct uncontaminated water away from the holding areas. See Chapter 2.1 of this document for more information on clean water diversions. CAFOs may also cover manure stockpiles in the feedlot to reduce nutrient losses and reduce contaminants in runoff. CAFOs can further reduce the generation of waste by minimizing the amount of fresh water used to flush milking parlors and eggwash areas, and using recycled water from a lagoon or holding basin to flush animal housing areas. In addition, a few CAFOs have retrofit flush systems with dry manure handling systems (such as belts, dry bedding systems, scrapers, or v-shaped pits) to significantly reduce the amount of water used in manure handling. This can significantly reduce the costs for CAFOs to both haul and land apply manure.

For unroofed confinement areas such as dry lots, CAFOs must have a system for collecting and containing contaminated runoff. CAFOs can accomplish this by using curbs at the edge of paved lots and reception pits where the runoff exits the lots, or by using diversions, sediment basins, and underground outlets at unpaved lots. At unpaved beef feedlots, operators can carefully remove manure so as not to break the partial seal on the soil the manure has created. This seal, though not completely impermeable, does help reduce the downward movement (leaching) of contaminated water. CAFOs should routinely add soil to earthen lots to fill in holes and to assist with retaining the originally designed grade of the lot.

The amount of manure generated at a CAFO is linked directly to the number of animals maintained. However, because the composition and concentration of manure changes as it ages, the amount collected and applied to the land is often less than the amount initially generated by the animals. To estimate the amount of manure, litter, and other process wastewater that will be available for land application, CAFOs should calculate the quantity of manure, litter, and other process wastewater stored on site and the quantity of manure, litter, and process wastewater removed from the production area for uses other than application to the CAFO's land application areas. Any estimates should include all process wastewater such as milk parlor wash water and egg wash water, if appropriate. See Appendix D for methods for estimating the amount of animal waste in a pile, pond, or lagoon.

2. Manure Sampling and Testing

The CAFO rules require that samples of manure be collected and analyzed for nitrogen and phosphorus a minimum of once per year (412.4(c)(3)). Because the nutrient content of manure may vary throughout the year and depends on many site-specific factors (e.g., composition of feed ration, number of different rations, type and amount of bedding, amount of water added or lost), results of representative annual nutrient sampling helps the CAFO develop the appropriate rate at which to land apply manure. Although the CAFO rules require that manure be analyzed only for nitrogen and phosphorus, CAFOs should consider analyzing the manure for percentage of dry matter, ammonium nitrogen, calcium, manganese, magnesium, sulfur, zinc, copper, pH, and electrical conductivity (a common measurement of total dissolved salts) to better assess the resource value of the manure. CAFOs can also conduct additional analyses on pathogen levels. CAFOs should check with their permitting authority for the list of analyses to be conducted and with their state and local Cooperative Extension Offices for acceptable procedures and sources of analysis.

Note that a CAFO should collect samples from all manure storage areas, both liquid and dry, as well as any wastewater or storm water storage areas, in order to obtain representative test results.

To develop better estimates of the nutrient content of manure, ideally CAFOs should sample manure each time it is removed from the production area. Collect samples as close to the time of land application as possible, leaving sufficient time between sampling and land application to obtain and interpret the results of the analyses. If bedding is provided for the animals, CAFOs should include both spent bedding and manure in the representative samples. CAFOs should sample each form of animal waste stored on site (e.g., stockpiled solids, separated solids, lagoon or pond liquid, lagoon or pond sludge) not only because the composition of each will be different, but because they often are applied to the land separately from each other. For example, liquids from a holding pond may be irrigated weekly to a neighboring field, whereas the solids may be land applied just once or twice per year to remotely located fields. See Appendix E for a description and examples of commonly used sampling procedures for solid waste, semi-solid waste, liquid waste, and poultry litter.

Photo by USDA NRCS

3. Soil Sampling and Testing

Soil testing is an important tool for estimating nutrients available for uptake by a crop. A soil test is a laboratory procedure that measures the plant-available portion of soil nutrients. This measurement is used to predict the amount of nutrients that will be available during the growing season. In a traditional soil test, analyses are conducted for pH, nitrogen, phosphorus, potassium, soil organic matter, and electrical conductivity. The CAFO rules require that soil be analyzed for phosphorus at least once every five years. When conducting soil sampling, a

Soil Sampling

ANSI GELPP 004-2002, *Manure Utilization,* standard recommends sampling soils every three years and analyzing them for, at minimum, nitrate content, available phosphorus content, pH, and buffer pH.

EPA also recommends periodically analyzing the soil sample for nitrogen, potassium, pH, salinity, metals, micronutrients, and organic matte to better assess the soil conditions at a land application site.

representative soil sample should be collected at each land application site and analyzed.

Generally, the soil test report contains the laboratory test results and fertilizer and liming recommendations for the next two crops in the rotation. The report also includes information regarding the recommended time and method of fertilizer and lime applications. In certain parts of the country, the pre-plant nitrate test and pre-side-dress nitrate test are used to determine whether additional nitrogen is necessary after the crop begins growing.

CAFOs should sample each field management unit where manure is applied. Different field areas may have different soil types, past cropping histories, or different production potentials, so each field should be sampled and managed separately. To ensure a *representative* soil sample from each field, CAFOs should collect several samples around the field at the appropriate depth and thoroughly mix all samples; see Example 4-1. Part of this mixed soil should be apportioned as a representative sample for the entire field management unit. Next, samples for each field should be sent to an accredited laboratory for analyses. An accredited laboratory is one that has been accepted in one or more of the following programs:

- A state-certified program;
- The North American Proficiency Testing Program (Soil Science Society of America); or
- Laboratories participating in other programs whose tests are accepted by the Land Grant University in the CAFO's state.

Pre-Sidedress Soil Nitrate Test (PSNT)

The PSNT is a widely used tool for optimizing nitrogen fertilizer use efficiency for corn production. The test relies on timely measurement of mineralized soil nitrate in the top layer of soil just prior to corn's period of rapid nitrogen uptake. The PSNT is highly recommended for corn fields where manure (and other organic sources of nitrogen) have been applied recently. The PSNT may be less reliable when total nitrogen application prior to sidedress exceeds 50 pounds nitrogen per acre. CAFOs should consult their local Extension Service for more information.

Soil P Test

A soil sample from the site is necessary to assess the level of "available P" in the surface layer of the soil. The available P is the level customarily given in a soil test analysis by the Cooperative Extension Service or commercial soil test laboratories. These ranges of soil test P values will vary by soil test method and region. The soil test level for "available P" does not ascertain the total P in the surface soil. It does however, give an indication of the amount of total P that may be present because of the general relationship between the forms of P (organic, adsorbed, and labile P) and the solution P available for crop uptake.

Example 4-1: Soil Sampling Depths

According to USDA-ARS publication *Agricultural Phosphorus and Eutrophication*, it is the surface inch or two in direct contact with runoff that are important when using soil testing to estimate phosphorus loss. At the same time, phosphorus may be transported to drain tiles or ground water by leaching. Soil samples should be collected to 2 inches when the subsurface drainage tiles are not present and the CAFO owner or operator intends to surface apply manure without incorporation.

Soil fertility specialists at state Land Grant Universities have conducted extensive research to determine the most suitable extraction solutions for the local soils, to correlate soil tests and crop yields, and to calibrate soil tests with nutrient recommendations. These specialists can provide valuable information and services to ensure accurate testing.

The analytical results from a soil test extraction are relatively meaningless by themselves. Soil nutrient levels should be interpreted by the CAFO or a certified nutrient management specialist to determine the plant-available nutrients in the soil. Most soil test laboratories use qualitative terms such as “low,” “medium or optimum,” and “high or very high” to describe the results, which are related to quantities of nutrients extracted. When several samples are collected from the same field, the soil test results for all samples should be compared to determine the best application rate for the manure. See Appendix F of this manual and NRCS Practice Standard 590, *Nutrient Management* for information on soil sampling, soil testing, and soil analysis interpretations.

B. Protocols to Land Apply Manure

The CAFO rules require CAFOs to determine and implement site-specific nutrient application rates that comply with the technical standards for nutrient management established by the permitting authority. These standards must, among other things, address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing phosphorus and nitrogen transport to waters of the U.S. Chapter 6 of this manual discusses technical standards for land application.

> **Protocols for Land Application**
>
> **§122.42(e)(1)(viii)** Establish protocols to land apply manure, litter or process wastewater in accordance with site specific nutrient management practices that ensure appropriate agricultural utilization of the nutrients in the manure, litter or process wastewater.

CAFOs should use the following process to help ensure land application practices are appropriate:

- Review the latest state technical standards;
- Conduct a field specific assessment;
- Identify planned crop rotations and document crop nutrient requirements;
- Calculate the appropriate nutrient (manure) application rate;
- Use an appropriate manure application method;
- Evaluate the timing of all animal manure applications as specified in the technical standards;
- Understand restrictions to manure application; and
- Calibrate and inspect land application equipment.

Part of the protocol to land apply manure is the preparation of a Nutrient Management Plan. The requirements for a nutrient management plan are discussed in more detail below. NRCS Practice Standard 590, *Nutrient Management*, also recommends that nutrient management plans be used whenever plant nutrients and soil amendments are applied to the land, and the plan should not be limited to manure applications.

1. Nutrient Management Plan

All CAFOs that apply manure, litter, or process wastewater to a land application area must develop and implement a Nutrient Management Plan (NMP) that addresses each land application area. For Large CAFOs the NMPs must address the following[1]:

- Protocols for testing manure, litter, process wastewater, and soil (see Section A of this chapter);
- The land application protocol consistent with the technical standards established by the permitting authority;
- The manure, litter, or process wastewater application rate calculations (see Section B.5 of this chapter);
- Calibration and inspection of land application equipment (see Section B.8 of this chapter);
- Recordkeeping (see Section C of this chapter); and
- Site-specific conservation practices (e.g., practices to control erosion less than or equal to "T") to control runoff of pollutants into surface water bodies (see Section D of this chapter).

> **Additional Conditions Applicable to Specified Categories of NPDES Permits**
>
> **§122.42(e)(1)** At a minimum, a nutrient management plan must include best management practices and procedures necessary to implement applicable effluent limitations and standards.
>
> **Best Management Practices (BMPs) for Land Application of Manure, Litter, and Process Wastewater**
>
> **§412.4(c)(1)** The CAFO must develop and implement a nutrient management plan that incorporates the requirements of paragraphs (c)(2) through (c)(5) of this section based on a field-specific assessment of the potential for nitrogen and phosphorus transport from the field and that addresses the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters.

The development of a NMP involves the assessment of manure nutrients generated on the CAFO and the land available (owned or under operational control by the CAFO owner/operator) to apply those nutrients at the proper application rate. By requiring CAFOs to apply manure at the appropriate nutrient application rate, EPA expects that some commercial fertilizer application will be replaced by manure application (for additional discussion refer to EPA's *Development of Pollutant Loading Reductions from Revised Effluent Limitation Guidelines for Concentrated Animal Feeding Operations*). All excess nutrients beyond the amount needed for appropriate land application at the CAFO must be transported off site for land application, properly used or properly disposed of.

The NMP must address the nine minimum elements EPA has determined are needed to protect water quality. These minimum elements require a description of how CAFOs will achieve each of the following (also see Chapter 2 of this document):

- Adequate storage capacity;
- Proper management (handling and disposing) of dead animals;
- Diverting clean water from the production area (clean water management);
- Preventing animals from contacting waters of the U.S.;
- Proper chemical handling;

[1]Some of the listed requirements apply to all CAFOs under 40 CFR 122.42 while others apply only to Large CAFOs under the Effluent Guidelines at 40 CFR 412.4.

- Implementing conservation practices to control nutrient loss;
- Testing manure, litter, process wastewater, and soil;
- Methods for the land application of manure, litter, and process wastewater; and
- Keeping records.

EPA's *Producers' Compliance Guide* for CAFOs and the *Permit Guidance* provide additional discussion of these minimum elements. In addition, see Chapter 6 for more information on developing and using technical standards for the land application of manure, litter, and process wastewater.

2. Required Nutrient Management Plan Format

NMPs do not need to be written in a particular scheme or format. This provides flexibility in developing a plan to meet the CAFO rule minimum measures and practices and other requirements. If a state already requires a NMP that includes some, but not all of the minimum elements, then only the missing elements would need to be incorporated into the existing plan. Some states may already require NMPs that meet the requirements of this rule, therefore, some CAFOs may not need to develop a new plan. For example, some states already require a Manure Management Plan (MMP). CAFOs must ensure that their MMP, NMP, CNMP, or equivalent plan contains all of the elements required by the CAFO regulations.

3. Plan Certification

The CAFO regulations encourage, but do not require, NMPs to be developed by certified planners. However, due to the complexity of the plans and the variety of expertise that is needed to develop a sound NMP, EPA expects that CAFO owners/operators will seek technical advice from local NRCS, Cooperative Extension, and Land Grant University staff as well as private technical planners. These certified specialists are available nationwide to help CAFOs prepare NMPs. Generally, nutrient management specialists must complete a precertification training course, pass an examination, and receive continuing education on a variety of topics. To earn certification, nutrient management planners have competence in or an understanding of soil science and soil fertility, nutrient application and management, crop production, soil and manure testing and result interpretation, fertilizer materials and their characteristics, best management practices for use of nutrients and water management, environmental and economic impacts associated with improper nutrient management, and all applicable laws and regulations.

4. Comprehensive Nutrient Management Plans

EPA encourages all CAFOs to go beyond the minimum regulatory requirement to develop a nutrient management plan and to develop a full-fledged Comprehensive Nutrient Management Plan. Whether a CAFO develops a CNMP or not, EPA recommends that CAFOs and their consultants use USDA's CNMP Guidance to assist in developing the NMP. However, it should be noted that following this CNMP Guidance does not guarantee that a CAFO's CNMP will adequately address all of the minimum elements that are required by the regulations for a nutrient management plan. Each CAFO that develops a CNMP as a way to meet their regulatory requirement for a nutrient management plan is responsible for ensuring that its CNMP has all of the required minimum elements for a nutrient management plan.

Accredited NMP Organizations

Approved organizations for certifying nutrient management specialists include:
- USDA;
- Certified Crop Advisor Program of the Amercian Society of Agronomy;
- Land Grant University Certification Programs;
- National Alliance of Independent Crop Consultants;
- State Certification Programs; and
- American Registry of Professional Animal Scientists.

5. Crop Rotations and Crop Nutrient Requirements

To develop appropriate land application practices, CAFOs should identify planned crop rotations. A rotation is the growing of a sequence of crops to optimize yield and crop quality, minimize the cost of production, and maintain or improve soil productivity. CAFOs should describe their planned sequence of crops (e.g., corn for silage, soybeans), preferably for 5 years. This should include planting and harvesting dates and residue management practices. When developing NMPs, CAFOs should start with last year's crop and project the crop rotation for the next four years. Crop rotation is important in calculating total nutrient needs over the period of the rotation, nutrient buildup, and nutrient removal via harvesting.

Benefits of Crop Rotations

A cropping sequence with a variety of crop types (grasses, legumes) and rooting characteristics (shallow roots, deep roots, tap roots) better uses available soil nutrients. Following a shallow-rooted crop with a deep-rooted crop helps scavenge nutrients that might have moved below the root zone of the first crop.

Source: CORE4 Conservation Practices, August 1999

After identifying crop rotation, CAFOs should determine and document the crops' nutrient requirements (i.e., nitrogen, phosphorus, and potassium) and include a description of the expected crop yield. Plant growth can require more than 20 chemical elements; 16 of these elements are considered essential for plant growth. The primary essential elements include nitrogen, phosphorus, and potassium. Nutrient requirements of specific crops are readily available from state and local Cooperative Extension Offices.

Sixteen Essential Elements for Plant Growth

Carbon	Iron
Hydrogen	Manganese
Oxygen	Boron
Nitrogen	Molybdenum
Phosphorus	Copper
Potassium	Zinc
Calcium	Chlorine
Magnesium	Sulfur

Source: Chesapeake Bay Region Nutrient Management Training Manual

The total nutrient requirements for fields are largely based on the CAFO's expected crop yields. Generally, the higher the yield expectation, the higher the nutrient requirement. Methods for calculating expected yield goals include using past crop yields for that field, county yield records, soil productivity tables, or local research. Expected yields should be based on realistic soil, climate, and management parameters. An unrealistic estimate can result in either too many or too few nutrients being applied. Because climate can significantly affect yields, CAFOs should base expectations on data from at least the last 5 years. Given a crop rotation, Cooperative Extension Offices and/or soil laboratories can and often do provide recommended quantities of nutrients/amendments to meet the expected yield. This recommendation usually takes the current soil test for that field into consideration, and may be used as the calculated crop nutrient requirements for that year.

Phosphorus Index

The ranking of a Phosphorus Index (PI) identifies sites where the risk of phosphorus movement may be relatively higher than that of other sites. When the parameters of the index are analyzed, it will become apparent that an individual parameter or parameters may be influencing the index disproportionately. These identified parameters can be the basis for planning corrective soil and water conservation practices and management techniques. If successful in reducing the movement of phosphorus, the concern of phosphorus enrichment will also be reduced. The PI provides a method for developing management guidelines for phosphorus at the site to lessen their impact on water quality. See Appendix H for more details.

6. Application Rate

The effluent guidelines require that application rates for manure, litter, and other process wastewater must minimize P and N transport from the field to waters of the U.S. in compliance with technical standards for nutrient management established by the permitting authority (40 CFR 412.4(c)(2)). Under these regulations, the State's technical standards must include a field-specific assessment that in general will provide information needed to determine whether land application of manure is appropriate for a site and the basis (e.g. nitrogen or phosphorus) for the application rate. EPA anticipates that most states will use the results from the Phosphorus Index to determine whether animal waste should be applied on a nitrogen or phosphorus basis. See Chapter 3 of the *Permit Guidance* for more information on technical standards for nutrient management. See Chapter 6 of this document for example technical standards and their use in developing a NMP.

Nitrogen-based application rates are generally based on the following factors: (1) the nitrogen requirement of the crop to be grown based on the operation's soil type and crop; and (2) realistic crop yields that reflect the yields obtained for the given field in prior years or, if not available, from fields obtained for the same crop at nearby farms or county records. Once the nitrogen requirement for the crop is established, the manure application rate is generally determined by subtracting any other sources of nitrogen available to the crop from the crop's nitrogen requirement. These other sources of nitrogen can include residual nitrogen in the soil, nitrogen credits from legumes, crop residues, irrigation water, and biosolids. Application rates are based on the nitrogen content in the manure and should also account for application methods, such as incorporation, and other site-specific practices. Phosphorus-based application rates generally take into account the phosphorus requirements of the crop, as well as the amount of phosphorus that will be removed from the field when the crop is harvested.

The current NRCS Nutrient Management technical standard describes three field-specific risk assessment methods to determine whether the land application rate is to be based on nitrogen or phosphorus, or whether land application is to be avoided. These three methods are: (1) Phosphorus Index; (2) Soil Phosphorus Threshold Level; and (3) Soil Test Phosphorus Level. The permitting authority has the discretion to determine which of these methods, or other State-approved alternative method, is to be used. EPA anticipates that State standards will generally provide CAFOs the flexibility to determine, separately for each field, whether manure is to be applied at the nitrogen- or the phosphorus-based rate. Thus, EPA expects that as the requirements are implemented, some CAFOs will be able to apply manure at the nitrogen-based rate for all of their fields; some CAFOs will be limited to the phosphorus-based rate on all of their fields; and the remaining CAFOs will have some fields that are limited to the phosphorus-based rate and some fields where manure can be applied at the nitrogen-based rate. In making these field-specific determinations, CAFOs must use the method authorized by the permitting authority.

The objective of determining an application rate is to match, as closely as possible, the amount of available nutrients in animal manure with the amount required by the crop. The basic equation for calculating agronomic application rates for manure is:

Agronomic application rate	=	Crop nutrient requirement − nutrient credits
Crop nutrient requirement	=	Crop nutrient uptake × crop yield
Nitrogen credits	=	Legume nitrogen credits + nitrogen residual from past manure applications + nutrients from commercial fertilizer applications + irrigation water nitrate nitrogen + crop residues + other nitrogen credits

Essentially, nutrient credits are all other nutrients available to the crop in addition to the nutrients in the manure. Each of these credits is described further below.

- **Credits from previous legume crops**. Atmospheric nitrogen is fixed by legume plants and brought into the soil. Amounts of nitrogen added by legume production vary by plant species and growing conditions. CAFOs should check with their local Cooperative Extension Office or Land Grant University to determine appropriate legume credits for crop rotations.

- **Residuals from past manure applications.** Nitrogen is a mobile nutrient that occurs in the soil and plants in many forms. Not all nitrogen in manure that CAFOs apply is available to the crop during the year of application. Some of the nutrients require organic material decomposition before they are made available for plants. A percentage of last year's nitrogen and a smaller percentage of previous year's nitrogen will become plant-available during the current crop season. For example, 12 percent of organic nitrogen might be available from one year ago, 5 percent might be available from two years ago, and 2 percent might be available from 3 years ago. Because these values depend on type of animal waste and local climate, CAFOs should use mineralization rates from their local Cooperative Extension Office to determine the amount of nitrogen available from previous manure application. Even though phosphorus also undergoes a mineralization process, phosphorus and potassium are typically considered 100 percent plant-available the year of application. The phosphorus in the soil is also reflected by the current soil test. Therefore, typically little or no residual amounts of phosphorus and potassium are calculated.

- **Nutrients supplied by commercial fertilizer and biosolids.** Pound-for-pound, animal manure does not have the same nutrient value as commercial fertilizer, and commercial fertilizer can be customized and blended to meet specifications. Farmers often supplement animal manure applications with commercial fertilizer or biosolids. Furthermore, because animal manure contains relatively high concentrations of phosphorus, crops generally are not supplied with enough nitrogen when manure is applied on a phosphorus basis. Therefore, CAFOs may need commercial nitrogen fertilizer to meet the crop's total nitrogen requirements when manure is applied at less than the nitrogen rate. CAFOs must include the nutrient contribution from these other sources in the manure application rate calculations.

- **Irrigation water.** Irrigation water, especially from shallow aquifers, contains some nitrogen in the form of nitrate nitrogen. Also, water from runoff ponds and storage lagoons contains nutrients. CAFOs must include these nutrient sources in the NMP. To calculate the amount of nitrogen applied with irrigation water, CAFOs must conduct a nutrient analysis to determine the concentration of nitrogen and phosphorus in the water typically reported as nitrate nitrogen and soluble phosphorus in parts per million (ppm), or milligrams per liter (mg/l).

The use of animal manure as a nutrient source requires careful planning because the nutrients contained in the manure are generally not in the proportion needed by crops. While most animal manure has a nitrogen-phosphorus-potassium ratio from 3-2-3 to 2-1-2, crops typically require nutrients in a ratio ranging from 3-1-2 to 8-1-3. For this reason, applying animal manure based on one of the crops' nutrient requirements usually creates either a nutrient deficiency or excess for the other two nutrients.

Most state guidelines/policies already allow animal manure applications at rates sufficient to meet, but not exceed, the nitrogen needs of agronomic crops. In areas with relatively high soil phosphorus levels, states should recommend that animal manure be applied at rates sufficient to meet, but not exceed, the phosphorus needs of agronomic crops.

Excess levels of phosphorus build up in the soil at a rate that depends on the soil

Soil Nitrogen Leaching Index

Field staff, watershed planners, and land owners/operators use the Leaching Index (LI) to assist in evaluating various land forms and management practices for potential risk of nitrogen movement to water bodes. Appendix G provides more details.

type, soil test method, and excess level of phosphorus application. According to NRCS's CORE4 Conservation Practices Training Guide, it takes between 8 to 16 pounds of excess phosphorus to raise the soil test level of phosphorus by 1 pound. Many states have developed a relationship between soil test levels of phosphorus and the potential for significant phosphorus movement to surface or groundwater. States should set threshold soil test levels of phosphorus at which either animal waste application rates should be based on the crops' phosphorus requirements or management practices should be put into place to control runoff and erosion. For very high soil test phosphorus levels, this should include a total restriction of additional phosphorus application to the field; see examples 4-2 through 4-4 for example State regulations setting specific limits for phosphorus applications and erosion.

Example 4-2: Example State Restriction of Additional Phosphorus Applications

Livestock waste must not be applied to land where the Bray P1 or Mehlich soil test for elemental Phosphorus is greater than 300 pounds per acre for the top 7 inches of the soil profile.

Example 4-3: Sample State Technical Standard to Minimize Transport of Insoluble Pollutants

Based on a soil test for elemental Phosphorus, the following limitations apply:

soil test P > 150 ppm: no manure application
soil test P > 75 ppm: manure application containing up to 2 years crop needs
soil test P < 75 ppm: nitrogen based rates

Example 4-4: Sample State Technical Standard to Minimize Transport of Insoluble Pollutants

Adequate erosion and runoff controls to meet soil loss tolerance level or "T" must be used to prevent discharge of livestock waste to waters of the state.

Phosphorus Transport Factors

According to USDA planning guidance, the factors influencing phosphorus movement include transport, phosphorus source, and management factors. Transport factors are the mechanism by which phosphorus moves within the landscape, such as rainfall, irrigation, erosion and runoff. Factors which influence the source and amount of phosphorus available to be transported are soil content and form of phosphorus applied. Phosphorus management factors include the method and timing of application such as application equipment and tillage practices.

Phosphorus movement in runoff occurs in both particulate and dissolved forms. Particulate phosphorus is attached to mineral and organic sediment as it moves with the runoff. Dissolved phosphorus is in the water solution. In general, particulate phosphorus is the major portion (75-90 percent) of the phosphorus transported in runoff from cultivated land. Dissolved phosphorus makes up a larger portion of the total phosphorus in runoff from non-cultivated lands such as pastures and fields with reduced tillage. In terms of their impact on eutrophication of water bodies, particulate phosphorus becomes less available to algae and plant uptake than dissolved phosphorus because of the chemical form it has with the mineral (particularly iron, aluminum, and calcium) and organic compounds. Dissolved phosphorus is 100 percent available to plants. Added together, the available portion of particulate phosphorus and the dissolved phosphorus represents the phosphorus that promotes eutrophication of surface waters. The interaction between the particulate and dissolved phosphorus in the runoff is very dynamic and the mechanism of transport is complex.

Multi-Year Phosphorus Application Rate

In some situations, the application equipment may not be able to apply manure at the recommended phosphorus application rate because that rate is lower than the spreading capability of the equipment. Therefore, when permissible under the State's technical standards, CAFOs may elect to use a multi-year phosphorus application rate until the equipment is replaced. In other cases, the risk of runoff is low and it may be more practical and economical to "bank" phosphorus by applying manure at rates higher than the crop's phosphorus needs for that year, again, where appropriate under the State standards. In both examples, the *multi-year phosphorus application rate* consists of applying a single application of manure at a rate equal to the recommended phosphorus application rate or estimated phosphorus removal in harvested plant biomass for the crop rotation for multiple years in the crop sequence. These applications may provide the phosphorus needed for multiple years. In this situation, CAFOs must not apply additional phosphorus to these fields until the amount applied in the single year had been removed through plant uptake and harvest. However, even under the multi-year application rate for phosphorus, CAFOs cannot exceed the annual nitrogen rate for the year of application. State standards generally will not allow this method at land application areas with a high potential for phosphorus runoff to surface water. CAFOs should check with their permitting authority to determine the appropriateness of using a multi-year phosphorus application rate.

Application Rates Based on Other Parameters

In some areas, animal waste application rates might need to be based on parameters other than nutrients. For example, trace metals present in animal wastes, when applied at either nitrogen- or phosphorus-based rates, are made available to plants in sufficient quantities that they provide many of the micronutrients necessary for plant growth. Excessively high levels of these trace metals, however, can inhibit plant growth. By limiting manure applications to the nitrogen- or phosphorus-based rate, CAFOs will also be limiting the rate at which metals are applied to fields and thus reduce the potential for applying excessive amounts of the trace metals. In other regions of the country where farmlands are overloaded with salt, the salt content of animal waste, often measured as electrical conductivity, might be the appropriate parameter for limiting land application rates. When using any of these alternative application rates, CAFOs must ensure appropriate agricultural utilization of the nutrients in the manure as discussed above (see 40 CFR 122.42(e)) and 412.4(c)]. In no case may manure be applied at rates greater than the annual nitrogen needs of the crop(s). See Appendix I for information on calculating nutrient application rates.

7. Application Method

CAFOs should always apply manure uniformly and at the approved application rates. Under the effluent guidelines, CAFOs must record the date (day, month, year) and method of each manure application (see 40 CFR 412.37(c)). Although many equipment options exist, there are basically two general methods of application: subsurface application and surface application. The method of application is generally dictated by the form of the waste (i.e., solid, semisolid, liquid).

- Subsurface application. Solid, semisolid, and liquid waste can all be applied using this method. When feasible, this is the preferred method of manure application. CAFOs use this method by mechanically incorporating or injecting the manure into the soil. Mechanical incorporation can be performed using moldboard plows, chisel plows, or heavy discs. To reduce nutrient losses, CAFOs should incorporate wastes applied to the land surface before it dries, usually within two days of application. Injection requires a liquid manure spreader and equipment to inject manure below the soil surface. To prevent nutrient losses, CAFOs should close the openings made by the injectors following application.

Immediately incorporating manure in the spring will increase the amount of plant-available nitrogen by reducing ammonia loss. Incorporation in soils with low runoff potential can help prevent the movement of nutrients and pathogens from animal manure to surface waters. Where soil erosion is a problem, however, tillage might result in unacceptable losses of soil and nutrients.

Injection is likely the best method of incorporating liquid and semisolid animal manure in reduced-till or no-till cropping systems because crop residues left on the surface act as a mulch, and the exposed soil surface is minimal.

- Surface application of liquid waste (irrigation). The three predominant systems used for surface application of liquid animal wastes (irrigation) are solid sets, center pivots, and traveling guns. Solid set systems are a series of sprinklers generally supplied by underground pipe. Center pivot systems are generally used in large fields and must be able to travel in a circle. Traveling guns are high-pressure, high-output, single-nozzle systems that crawl down travel lanes in the field. Liquid wastes also can be surface applied with tank spreaders.

Irrigation can save considerable amounts of time and labor when applying large volumes of wastewater or liquid animal waste. Sometimes CAFOs may need to dilute liquid animal wastes with fresh water for salinity or other plant requirements, or to facilitate application via irrigation. Irrigation provides flexibility in applying animal wastes during the growing season and has the added advantage of supplying water during the growing season's drier periods. Infiltrating liquid can carry much of the easily volatilized ammonia into the soil, although some ammonia will still be lost from the spray before it reaches the soil.

The irrigation system should, however, be matched to the topography, cropping program, nutrient, and water needs of the crops, as well as infiltration, percolation rate, and water holding capacity of the soil. CAFOs should not use irrigation to apply animal wastes unless solids have been removed or chopped very fine. If solids are present, the nozzles will clog and the system will not operate properly. Irrigation also may produce aerosol sprays that can cause odor problems.

- Surface application of dry, solid manure. This application method is very effective at applying dry, bulky animal wastes such as poultry litter. Box spreaders with a chain-drag delivery to a fan or beater spreader mechanism, or tank wagons equipped with splash plates typically are used for surface applications.

Although this is a relatively easy method for applying animal manure and wastes to the land, it has several disadvantages. First, when manure is applied to the surface of the soil without incorporation, most of the unstable, rapidly mineralized organic nitrogen from the manure is lost through the volatilization of ammonia gas. Volatilization increases with time, temperature, wind, and low humidity. Surface application without incorporation also increases the likelihood of nutrient losses via surface runoff. Surface runoff losses are more likely on soils with high runoff potential, soils subject to flooding, soils that are snow-covered or frozen (via runoff once the snow melts or soil thaws), and soils with little or no vegetative cover. Second, aerosol sprays produced by mixing manure and air during this type of application can carry odors considerable distances. Third, this application method provides poor distribution of nutrients, which can be aggravated by heavy winds. In addition, precision application of manure and waste, such as poultry litter, with a geared box spreader can be difficult.

CAFOs can reduce nutrient losses when using surface application by implementing soil conservation practices such as contour strip cropping, crop residue management, cover crops, diversion terraces, vegetative buffer strips, and grass waterways. More information about conservation practices is available from the local soil and water conservation district and USDA's Natural Resources Conservation Service.

CAFOs must record weather conditions (e.g., rainfall amounts) at the time of application and for the 24-hour period before and after application (40 CFR 412.37(c)).

Irrigation Technologies

Irrigation application systems may be grouped under two broad system types: gravity flow and pressurized. Gravity-flow systems are particularly predominant in the arid West. Many irrigation systems rely on gravity to distribute water across the field. Land treatments (such as soil borders and furrows) are used to help control lateral water movement and channel water flow down the field. Water losses are comparatively high under traditional gravity-flow systems due to percolation losses below the crop-root zone and water runoff at the end of the field. See the text box at right for potential challenges of gravity-flow irrigation in meeting the CAFO requirements.

Gravity-Flow Irrigation

Water is conveyed to the field by means of open ditches, above-ground pipe (including gated pipe) or underground pipe, and released along the upper end of the field through siphon tubes, ditch gates, or pipe valves. Such systems are generally designed for irrigation water, and many CAFOs have not traditionally accounted for the irrigated manure nutrients. Some irrigation systems may offer nutrient management challenges to CAFOs including: uneven nutrient distribution, flooding and pooling, excessive volatilization of nitrogen, excessive leaching, and other potential difficulties in meeting technical standards established in their state.

Pressurized systems-including sprinkler and low-flow irrigation systems-use pressure to distribute water. Sprinkler system use is highest in the Pacific Northwest, Northern Plains, and in Eastern States. Center-pivot technology serves as the foundation for many technological innovations—such as low-pressure center pivot, linear-move, and low-energy precision application systems—that combine high application efficiencies with reduced energy and labor requirements. For more detail on irrigation water application technologies and a discussion of irrigation water management, see ARS' Irrigation Water Management in *Agricultural Resources and Environmental Indicators at http://www.ers.usda.gov/publications/ah712/AH7124-6.PDF*.

Low spot where water is ponding will reduce efficiency. Photo by USDA

8. Application Timing

Timing of manure application is an important consideration for nutrient availability. The longer manure nutrients are in the soil before crops take up the nutrients, the more those nutrients, especially nitrogen, can be lost through volatilization, denitrification, leaching, and surface runoff. CAFOs should consider the hydrological cycle and hydrological sensitivity of each field when making management decisions.

Best Management Practices (BMPs) for Land Application of Manure, Litter, and Process Wastewater

§412.4(c)(2)(i)) Include a field-specific assessment of the potential for nitrogen and phosphorus transport from the field to surface waters, and address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters.

- Spring applications. Applications made during this time are best for conserving nutrients because the threat of surface runoff and leaching diminish in late spring. This time period also is favorable because it is just before the period of maximum crop uptake, allowing for more efficient nutrient utilization.

- Summer applications. Early summer is a good time to apply manure because it is generally the time of maximum crop uptake. One consideration is improper manure application rates and methods can damage growing crops. Options for applying manure in the early summer include side-dressing manure by injecting it between crop rows, irrigating liquid manure over corn rows when the corn is 3 to 12 inches tall (taller corn stalks can suffer more leaf damage), or applying manure to forages such as hay fields and grasses after the first and second cuttings or to pastures with small stubble. CAFOs can also apply nutrients to harvested stubble fields in mid- to late-summer. Nitrogen in the manure stimulates more growth of cover crops, especially non-legume species that require nitrogen. The cover crop takes up the nutrients and holds them in an organic form in the plant, preventing them from leaching or being tied up in the soil complex. These nutrients are then more available for subsequent year's crops when the crop residue breaks down.

- Fall applications. Fall application of manure generally results in greater nutrient losses than occur from spring application regardless of the application method, but especially if the manure is not incorporated into the soil. Increased nutrient losses occur because mobile nutrients such as nitrogen leach out of the soil during this period. Many of the non-leachable nutrients react with the soil to form insoluble compounds that build soil fertility, but some are bound so tightly that they might not be available for the next crop. In fall, manure is best applied at low rates to fields that will be planted in winter grains or cover crops. If winter crops are not planted, CAFOs should apply manure to the fields containing the most vegetation or crop residues. Sod fields to be plowed the next spring are also acceptable, but fields where corn silage is removed and a cover crop not planted are undesirable sites.

- Winter applications. The greatest nutrient losses typically occur with winter manure applications. Research indicates that winter applications increase pollutants in runoff during spring thaw and rainfall events. Most of the seasonal runoff occurs during snowmelt in late winter or early spring. Manure applied in winter generally does not have the opportunity to dry and anchor to the soil surface or to be incorporated into the soil. CAFOs that apply manure during the winter must do so in compliance with the State's technical standards. Such protocols must account for the form of material that would be applied (e.g. liquid, semi-solid, or dry manure). In addition, such standards should address the time at which the materials would be applied relative to periods when runoff may occur, the fraction of precipitation that runs off the land in meltwater and in response to winter rains (as affected, in part, whether soil is frozen or not), the time it takes runoff to travel to waters of the United States (as affected by slope, distance to waters, roughness of the land surface, and whether or not runoff is in contact with the land surface), and other relevant factors, as appropriate. See Example 4-5 and Example 4-6 for sample State Technical Standards addressing timing of manure applications, and Appendix L for example technical standards addressing winter application of manure and waste water. Note manure, litter, and wastewater storage structures should include adequate capacity to store materials that accumulate during those times when, under the technical standards for nutrient management, land application would be prohibited.

Example 4-5: Sample State Technical Standard for Winter Application of Manure

CAFOs may only apply manure between November 15 and March 15 to those fields with less than 2% slope and not located closer than 2 miles to waters of the U.S.

The fields must not be subject to spring flooding. The manure should be incorporated into the soil unless a cover crop or 30% crop residue is maintained.

Example 4-6: Sample State Technical Standard for Application of Manure During a High Probability of Runoff

The owner of a dairy CAFO wants to surface apply liquid manure on a field tomorrow, October 20. Manure was last applied on the field in the spring and measurable rain has not fallen in the area for seven days. The field contains Lenawee silty clay loam and 30 percent residue from the harvested corn crop. When last completed, tillage was done on the contour. Subsurface drainage tiles are present in the field. The CAFO's permit prohibits surface application of manure if the National Weather Service forecasts a 50 or more percent chance of rainfall exceeding one inch, or less if a lesser rainfall event is capable of producing runoff, within 24 hours of the time of the planned application.

According to this state Technical Standard, can the CAFO owner apply manure on the field on October 20?

In the course of preparing his nutrient management plan, the producer previously determined that the field has a runoff curve number of 74 under average antecedent soil moisture conditions. The producer made this determination after consulting Table 2-2b and Appendix A in *Urban Hydrology for Small Watersheds* (USDA-NRCS 1986)(see Appendix M for these references). For the field in question, the producer also determined that 0.7 inches is the minimum quantity of water that is required to produce runoff from the field under average antecedent soil moisture conditions. The producer made this determination after consulting column 5 in Table 10.1 of the *National Engineering Handbook, Part 630, Hydrology* (USDA-NRCS 1993). On the morning of October 20, the producer goes to the following internet address: http://www.nws.noaa.gov/mdl/forecast/graphics/MAV/. The producer views the map that appears after selecting the precipitation product labeled, "24H Prob.>=0.5 in." According to the map, there is a 10 percent or less chance of 0.5 or more inches of rain in the upcoming 24-hour period. With this information, the producer has correctly concluded manure can be applied in this instance while remaining in compliance with his permit.

CAFOs should check their state regulations to determine whether fall or winter land application is allowed.

9. Equipment Calibration and Inspection

Inspect Land Application Equipment for Leaks

§412.4(c)(4) The operator must periodically inspect equipment used for land application of manure, litter, or process wastewater.

Operators of Large CAFOs must periodically inspect land application equipment for leaks (40 CFR 412.4(c)(4)). CAFOs must ensure land application equipment is operating properly (see standard permit conditions for operation and maintenance discussed in Chapter 2). CAFOs should calibrate land application equipment before each application to ensure that manure is delivered at the proper rate of application. Calibration defines the combination of settings and travel speed needed to apply animal waste at a desired rate. For example, spreaders can apply manure at varying rates depending on forward travel speed, power takeoff speed, gear box settings, discharge opening, swath width, overlap patterns, wind conditions, manure particle size, and many other parameters. There are two basic calibration techniques:

- The load-area method, which involves measuring the waste amount in a loaded spreader and then calculating the number of spreader loads required to cover a known land area; and
- The weight-area method, which requires weighing manure spread over a small surface area and computing the quantity of manure applied per acre.

The best calibration method depends on the type of spreader used. Soil-injection liquid spreaders should be calibrated using the load-area method because soil-injected waste cannot be collected. Liquid waste that is surface applied through a tank spreader is best measured by the load-area method because of the difficulty in collecting the liquid waste. CAFOs can successfully use either method to measure solid and semisolid waste. NRCS Practice Standard 590, *Nutrient Management*, recommends that land application equipment be calibrated to ensure uniform distribution of material at planned rates and ANSI GELPP 0004-2002, *Manure Utilization*, recommends annual calibration of manure application equipment. See Appendix J for more information on calibration of animal waste spreaders and irrigation equipment.

Though the CAFO rules do not specify the frequency of the inspections, EPA recommends inspections every time the equipment is used. This allows CAFOs to detect and then correct any potential problems before they cause adverse environmental impacts.

10. Additional Land Application Considerations

Although manure, litter, and process wastewater are valuable resources, they can also cause extensive damage if placed in environmentally sensitive areas or applied at inappropriate times. To protect water quality, CAFOs must not apply manure closer than 100 feet to any down-gradient waters of the U.S., open tile line intake structure, sinkhole, or agricultural well head, or other conduits to waters of the U.S. (unless the CAFO qualifies for a compliance alternative based on vegetated buffers or other alternative practices) (40 CFR 412.4(c)(5)). In addition, CAFOs should not apply manure in the following areas or under the following conditions:

- Near or in wetlands, riparian buffer areas, water sources, wells, drinking water supplies, high slope areas, and high erosion areas;
- Within concentrated water flow areas (vegetated or non-vegetated) such as ditches, waterways, gullies, swales, and intermittent streams[2];
- When the hydraulic load/irrigation water exceeds the infiltration rate of the soil;
- When crops are not being grown;
- When the ground is frozen or snow-covered (as described in Section 8); and
- When measurable precipitation is occurring on the day of application.

See Section 8 for a more detailed discussion of timing. The permit authority may include these types of requirements as technology-based standards.

11. NMP Review and Revision

CAFOs must keep a copy of the NMP on site (40 CFR 122.42(e)(2)). The NMP should be reviewed annually and revised every five years. Ideally, the NMP is re-certified every five years. CAFOs should review and modify NMPs, at a minimum, when the following events occur:

- Change in manure nutrients produced;
- Change in crop rotation;
- Change in farming operations or management systems;
- Change in technology or available data that affects land application; or
- New soil test analyses with revised recommendations.

[2] Note some of these features may be defined as waters of the U.S. If so, unpermitted discharges into them is directly prohibited. See the *Permit Guidance* for further discussion.

C. Records

The CAFO rules require CAFOs to maintain the following records for each site on which manure, litter, or process wastewater is applied(40 CFR 412.37(c) and 122.42):

- The Nutrient Management Plan for each site;
- Expected yield for each crop grown on the site;
- The date manure is applied to each site;
- Weather conditions at the time of application and for 24 hours prior to and following application;
- Test methods used to collect and analyze manure, litter, process waste water, and soil samples;
- Results of annual nitrogen and phosphorus manure analyses;
- Results of the phosphorus soil analysis required every five years;
- Explanation of the basis for determining the manure application rates, as provided in the technical standards established by the Director;
- The calculations for the amount of total nitrogen and total phosphorus to be applied to each field and the amount from all sources, including sources other than manure, litter, and process wastewater;
- The total amount of nitrogen and phosphorus actually applied to each field including documentation of calculations for the total amount applied;
- The method used to land apply the manure, litter or process waste water; and
- The dates of the inspections of the land application equipment.

Appendix C contains a sample checklist for the records that must be kept for a CAFO land application area.

D. Site-Specific Conservation Practices

Although animal manure is a valuable resource, it also can cause extensive damage if placed in environmentally sensitive areas or applied at inappropriate times. The effluent guidelines prohibit Large CAFOs from applying manure, litter, or process wastewaters within 100 feet of any down-gradient waters of the U.S., open tile line intake structures, sinkholes, agricultural well heads, or other conduits to waters of the U.S.

The rules also allow alternative ways to comply with this setback requirement as described below:

1. Required Setback or Buffer

A setback is an area where manure, litter, or process wastewater is not applied, but crops continue to be grown. A setback reduces pollution by increasing the distance pollutants in land-applied manure, litter, or process wastewater have to travel to reach surface water bodies. The CAFO rules require that manure, litter, and process wastewater not be applied closer than 100 feet to any down-gradient surface water, open tile line intake structure, sinkhole, agricultural well head, or other conduit to surface waters except under the two situations discussed below. This setback requirement helps ensure that nitrogen, phosphorus, and other pollutants (e.g., metals and pathogens) in manure do not reach waters of the U.S. after it is applied to the land. CAFOs may apply commercial fertilizer in the setback zone, and may grow crops in the setback zones, but CAFOs are encouraged to implement conservation practices in these areas.

2. Alternatives to Setbacks

There are two alternatives to the 100-foot setback requirement in the rule. First, the CAFO may establish a 35-foot wide vegetated buffer between the land application site and waters of the U.S. Second, the CAFO may demonstrate that the setback or the 35-foot vegetated buffer is not necessary due to the implementation of an alternative practice. Both of these alternatives are described below.

35-Foot Vegetated Buffer

A vegetated buffer is a permanent strip of dense perennial vegetation established parallel to the contours of and perpendicular to the dominant slope of the land application field. NRCS standards such as Practice 393 recommend appropriate species for cover. This generally includes native species. If the native species includes hay or alfalfa, CAFOs may choose such species in the vegetated buffer; however, for the area to continue to be considered "vegetated," CAFOs should not harvest it. The purpose of a vegetated buffer is to slow the runoff from a land application site, enhance the filtration of the runoff, and minimize the risk of nutrients and other pollutants leaving the land application site and reaching surface waters. CAFOs may not grow crops in the buffer or apply manure, litter, or other process waste waters to the buffer. NRCS standards recommend appropriate maintenance of the buffer, such as periodic sediment removal, nutrient removal, and vegetation trimming. Vegetated buffers are generally eligible for funding under USDA's Conservation Reserve Program continuous sign-up. In general, CAFOs can enroll in this program at any time and can receive incentive payments for the installation of the buffer and annual rental payments for the duration of the 10 to 15 year contract. For more information on USDA's Conservation Reserve Program see: http://www.fsa.usda.gov/pas/publications/facts/html/crpcont03.htm

Demonstration that the Setback is Not Necessary

CAFOs may demonstrate that the setback is not necessary due to implementation of alternative conservation practices or field specific conditions. Note that in the examples provided, it is the CAFO that must ultimately make the demonstration, even if the CAFO uses information generated by others. The CAFO should demonstrate that the alternative conservation practices or field-specific conditions will provide pollutant reductions of nitrogen, phosphorus, biochemical oxygen demand (BOD) and total suspended solids (TSS) equal to or greater than the reductions achieved by the 100-foot setback; see Example 4-7. EPA anticipates that some CAFOs will select this alternative as a proactive approach to protecting water quality. The regulations do not prescribe how the CAFO should make this demonstration; however, in general, CAFOs should not be allowed to use a small setback without implementing some additional controls. The demonstration of pollutant reductions should at a minimum address the runoff, leaching, and erosion of nutrients (nitrogen and phosphorus), BOD_5 (five-day biochemical oxygen demand), and solids.

Example 4-7: Setback Compliance

A Large CAFO has decided only a 5-foot setback is necessary because the field slope is less than 2 percent.

Did the CAFOs demonstrate that the setback is not necessary?

No, this does not meet the requirements of the effluent guidelines. The CAFO has not made any demonstration that the setback is not necessary by showing that the pollutant reductions of the site's 5-foot setback would equal those of a 100-foot setback. Indeed, it is highly unlikely that pollutant reductions from a 5-foot setback could be deemed equal to reductions from a 100-foot setback without implementation of additional practices.

CAFOs should not assume that meeting state best management practices (BMP) requirements or that all commonly used conservation practices (such as those discussed below) will always meet the demonstration requirement. For example, incorporation (i.e., tilling the manure into the soil) is a common and frequently encouraged management practice to minimize runoff. However, incorporating manure within 60 days before growing a crop may increase erosion such that a field no longer meets the equivalent of the 100-foot setback requirement. Appendix K includes a formula for calculating soil loss (erosion). CAFOs meeting current state requirements do not necessarily meet the 100-foot setback requirements; see Example 4-8.

Example 4-8: Incorrectly Assuming State Requirements Equals Setback

A state has requirements that all manure be injected or incorporated within 24 hours after land application. The CAFO injects all manure and decides no setback is necessary.

Did the CAFOs demonstrate that the setback is not necessary?

No, this does not meet the requirements of the effluent guildeline. The CAFO has not made any demonstration that the setback is not necessary. CAFOs should not assume conservation practices or best management practices already required by the state or locality are automatically equivalent to the 100-foot setback requirement.

State-Developed Alternative Conservation Practices. In some cases, a state may develop a list of alternative conservation practices that, in tandem with phosphorus-based technical standards for land application, have been evaluated and demonstrated to provide pollutant reductions better than the 100-foot setback. CAFOs should check to see whether their permitting authority has collected data and information that could be used to demonstrate that certain conservation practices provide pollutant reductions equivalent to or better than the reductions that would be achieved by the 100-foot setback. A state may also provide CAFOs with information or may specify suitable methods to facilitate the CAFO's demonstration; see Example 4-9.

Example 4-9: State-Developed Alternatives to Demonstrate Setback is Not Necessary

A Land Grant University has conducted extensive research in terraces and conservation tillage on many soil types native to the state and shown pollutant reductions better than that achieved by the 100 foot setback. The CAFO has soils and field conditions, and uses conservation practices, that are similar to those on which the Land Grant University has conducted the extensive research. The CAFO uses this information as the basis for its demonstration.

Did the CAFOs demonstrate that the setback is not necessary?

It is up to the permit authority to determine whether by relying on this information the CAFO has sufficiently demonstrated the setback is not necessary.

Soil Loss Tolerance (T)

Soil loss tolerance (T) is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely. See Appendix K for more details.

NRCS Conservation Plan. EPA encourages CAFOs to implement a combination of NRCS recommended practices in conjunction with the NRCS Practice Standard 590, *Nutrient Management*, for a given field. NRCS follows a 9-step process to develop a conservation plan; this process is described in detail in the USDA-NRCS *National Planning Procedures Handbook (NPPH)*, and may be found at: <http://policy.nrcs.usda.gov/>. An NRCS Conservation Plan is essentially a set of conservation practices that are designed to work in an integrated manner to accomplish an identified level of resource treatment. The development of a Conservation Plan includes determination of the baseline erosion and other associated losses, along with an evaluation of the practices that would meet the Tolerable Soil Loss “T.” Some Conservation Plans might call for additional efforts to achieve smaller erosion losses (i.e., if water quality standards are not met or the maximum amount of soil loss (T) is unacceptable for the site.) Therefore, an USDA Conservation Plan may be used to demonstrate pollutant reductions better than the 100 foot setback; see Example 4-10.

Example 4-10: Using a CNMP to Meet the Setback Requirements

A CAFO voluntarily develops a USDA-prepared CNMP. The CNMP includes a conservation planning component. This component includes modeling of baseline and calculation of improvements resulting from following the suggested practices. The CAFO refers to the calculations and modeling from the conservation planning component in the CNMP to make the demonstration of improved pollutant reductions over a 100 foot setback, and implements the conservation planning measures in lieu of the setback.

Did the CAFOs demonstrate that the setback is not necessary?

It is up to the permit authority to determine whether by relying on this information the CAFO has sufficiently demonstrated the setback is not necessary. EPA anticipates the Permitting Authority will find, in general, a certified CNMP will satisfy the requirement to demonstrate pollutant reductions better than the 100 foot setback.

E. Voluntary Conservation and Pollution Prevention Practices

Reducing the amount of runoff and eroded sediment that can reach surface water will in turn reduce the amount of nutrients that can reach the surface water. Numerous management practices to control runoff and soil erosion have been researched, developed, and implemented. Runoff and erosion control practices range from changes in agricultural land management (e.g., cover crops, diverse rotations, conservation tillage, contour farming, contour strip cropping) to the installation of structural devices (e.g., diversions, grade stabilization structures, grassed waterways, terraces). In addition to the required NMP, EPA strongly encourages all CAFOs to implement an approved USDA/NRCS conservation plan on all fields. Practices discussed in this section include: feeding strategies, and water conservation.

1. Feeding Strategies

Feeding strategies increase the efficiency with which animals use the nutrients in their feed, which decreases the amount of nutrients excreted in their waste. Example feeding strategies include, but are not limited to:

- Formulating feed to meet the animal's nutrient requirements (i.e., precision nutrition). This results in more of the nutrients being metabolized, thereby reducing the amount of nutrients excreted. This strategy has been successfully used for both swine and poultry.

- Multiphase feeding for cows and swine. This involves frequently changing the diet composition (such as weekly) for different groups of animals (e.g., lactating cows) to better match the changing nutritional requirements of the animal due to age, size, weight, or productivity.

- Reducing the particle size of the feed for swine by milling and pelleting. Note that this may decrease total nutrient excretion, but may require different approaches to manure handling and treatment. For example, solids separation is less efficient with manures where animals are fed a small pellet size.

- Use of phytase as a feed supplement for poultry and swine to help the animal birds digest phosphorus and reduce the amount of phosphorus they excrete.

- Using genetically modified feed for poultry and swine to make phosphorus more available for consumption, such as high available phytate corn.

- Reducing the dietary supplements, such as reduced phosphorus supplements added to grains fed to dairy cattle.

Because the manure generated when the various feeding strategies are used has lower nutrient content, more of the material can be applied to the land. As a result, CAFOs can use less land to apply all of the manure and, in some cases, transport smaller amounts of the material off-site for land application. In addition, strategies that focus on reducing the phosphorus concentration can turn the manure into a more balanced fertilizer in terms of plant nutrient requirements. Using these feeding strategies can result in potential cost savings in the form of reduced feed costs and reduced hauling/disposal costs since there is less manure to be transported for off-site land application.

2. Water Conservation

Water conservation is one way of reducing the volume of wastewater that is generated. EPA strongly encourages CAFOs to use a variety of practices to conserve water. These include, but are not limited to, using advanced watering systems, recycling flush water, and using dry scrape systems instead of wet flush systems.

Nipple water delivery systems reduce the volume of wastewater generated by only delivering water when the animals suck on the nipple. This reduces the spillage that occurs typically with trough and cup water systems and also reduces the contamination of the standing water in those systems by the animals. CAFOs can also use pressure sensors and automatic shutoff valves to reduce spillage in a watering system. A sensor can detect a sustained drop in water pressure resulting from a leak or break in a water line and shut off the flow to the broken line until it is repaired.

CAFOs can also conserve water by recycling the wastewater generated when waste collection gutters and alleys are flushed with water. CAFOs may need to treat the wastewater from the flushing operation prior to being recycled to remove pollutants and make the water acceptable for recycling.

Another water conservation method is a dry scrape system. In a dry scrape system, scrapers are used to push the manure through the collection gutters and alleys instead of water. This reduces the volume of water used in manure handling, which in turn reduces the volume of wastewater that has to be handled. Dry scrape systems are used for dry solid manure, semisolid manure, and for slurry manure while flush systems typically are used only for semisolid and slurry manure.

Tables

Figures

CHAPTER 5: VOLUNTARY PERFORMANCE STANDARDS FOR CAFOS

The examples contained in this chapter are for informative purposes only. The examples assume, but do not guarantee, that the CAFO meets all applicable federal, state, and local requirements.

EPA's long-term vision for CAFOs includes continuing research and progress toward environmental improvement. Currently, CAFOs, USDA, land grant universities, state agencies, equipment vendors, and other agricultural organizations, are working to develop new technologies to reduce: nutrient, pathogen, and other pollutant losses to surface water; ammonia and other air emissions; and groundwater contamination from animal manure. In the future, as these technologies are developed and improved, EPA believes that they may offer CAFOs the potential to match or surpass the pollutant reduction achieved by complying with the current requirements. At that time, EPA believes that some CAFOs will voluntarily develop and install new technologies and management practices equal to or better than the current requirements described in Chapter 2 of this manual in exchange for being allowed to discharge the treated effluent. (For the purposes of this chapter, the current technology controls required under the CAFO ELG described in Chapter 2 will be referred hereafter as the "baseline" technology requirements.) This is why EPA has created the *voluntary performance standards program* for CAFOs.

The *voluntary superior environmental performance standards* provision in 40 CFR 412.46(d) is available to new source Large CAFOs subject to 40 CFR Part 412, Subpart D (swine, poultry, and veal calves). This provision provides that these CAFOs may request from the Director alternative NPDES permit effluent limitations based upon a demonstration by the CAFO that site-specific innovative technologies will achieve overall environmental performance across all media that is equal to or superior to the reductions achieved by the baseline standards as provided by 412.46(a), which contains the Subpart D, new source CAFO production areas stadards. This chapter does not address the *voluntary superior environmental performance standards* for new swine, poultry, and veal CAFOs.

The remainder of this chapter presents an overview of the baseline requirements and the *voluntary performance standards program* which includes a description of who can participate in the program and how participation in the program will impact existing CAFO NPDES permits, as well as a step-by-step description of the requirements associated with participation in the program.

A. Overview of the Baseline Requirements

As described in Chapter 2, the baseline production area requirements for all existing beef, dairy, heifer, veal, swine, and poultry CAFOs are the same. However, baseline requirements vary for new operations. A summary of the requirements is presented in Table 5-1.

Table 5-1. Summary Description of Baseline Requirements

Existing and New Large Beef, Dairy, Heifer and Existing Large Swine, Poultry and Veal CAFOs
1. Baseline requirements prohibit the discharge of manure and process wastewaters. 2. A CAFO may discharge when rainfall events cause an overflow from a storage structure designed, constructed, operated and maintained to contain the following: • All manure, litter, and all process wastewaters including manure, wastewater, and other wastes accumulated during the storage period as reflected by the design storage volume (see Chapter 2 section B.1 of this document); • Direct precipitation from a 25-year, 24-hour rainfall event; and • Associated runoff from a 25-year, 24-hour rainfall event.

B. Overview of the Voluntary Performance Standards Program

> **Program Benefits**
>
> CAFOs are expected to derive substantial benefits from participating in this program, through greater flexibility in operation, increased good will of neighbors, reduced odor emissions, potentially lower costs, and overall improved environmental stewardship. EPA is considering other possible incentives to encourage participation in this program.

Under the voluntary performance standards program, existing and new Large beef, heifer, and dairy CAFOs and existing Large swine, poultry, and veal CAFOs are allowed to discharge process wastewater that have been treated by technologies that the CAFO demonstrates results in equivalent or better pollutant removals from the production area than would otherwise be achieved by the baseline requirements. Some CAFOs already achieve zero discharge and, in a few cases, will successfully demonstrate "no potential to discharge." This approach focuses on waste-generating operations, plus areas that have the potential to produce significant volumes of contaminated runoff such as freestall barn and yard areas, holding areas around milking centers, and unroofed feedlots. Although these voluntary programs are targeted toward the CAFO's wastewater discharges, EPA encourages operations electing to participate in the program to consider environmental releases holistically, including opportunities to lower releases to multiple environmental media.

1. Program Participation

All CAFOs electing to participate in the program should have a good compliance history (e.g., no ongoing violations of existing permit standards or history of significant noncompliance). In most cases, participation will result in an individual NPDES permit addressing the site-specific nature of the alternative technology and establishing site-specific discharge limitations.

2. Pollutants of Concern

In general, all CAFOs applying for the voluntary performance standards program must design the treatment technology to achieve equal or less quantities of BOD_5, total nitrogen (ammonia, nitrite/nitrate, and organic nitrogen), total phosphorous, and total suspended solids than the baseline system. EPA selected these parameters because of their high concentrations in manure-type waste streams and their impact on surface water quality if not treated. In addition, many conventional wastewater treatment technologies, in the process of treating these four selected pollutants, will result in treatment and removal of other pollutants. To qualify for voluntary alternative performance standards, the CAFO may also be required to remove other specific pollutants, such as pathogens and metals, if these pollutants are present in the waste stream at concentrations that may impact surface water quality, as determined appropriate by the permitting authority.

3. Required Technical Analysis

CAFOs requesting site-specific effluent limitations to be included in NPDES permits must submit a supporting technical analysis and any other relevant information and data that would support such site-specific effluent limitations. See section C of this chapter for more information.

4. Validation of Equivalent Pollutant Reductions

The CAFO must attain the limitations and requirements of a permit based on alternative technologies as of the date of permit coverage (40 CFR 412.31(a)(3). In the event these alternative limits will not be met as of the date of permit coverage, such as due to startup of certain wastewater treatment technologies, the permitting authority would need to incorporate a compliance schedule into an enforceable order that would establish milestones for implementing the alternative technologies and fully meeting the permit limitations. The permitting authority should consider whether it is appropriate to select a permit term that is less than five years to allow the permitting authority to evaluate whether the alternative technologies have resulted in the permit limitations being met.

If the permitting authority grants a request for voluntary alternative performance standards, the CAFO should, at a minimum, be required to take monthly effluent samples from the treatment system to verify continued permit compliance. The permitting authority may determine the CAFO must take more frequent samples (such as during start-up) or collect samples on a basis other than monthly (such as during all discharge events in the case of intermittent discharging technologies). CAFOs should be required to analyze for the following pollutants: BOD_5, total nitrogen, total phosphorous, and suspended solids. The permitting authority may also require a CAFO to monitor other pollutants on a regular basis. If monthly pollutant discharges from the alternative treatment system are greater than specified in the NPDES permit, a CAFO may be subject to both state and U.S. EPA enforcement actions.

General Versus Individual NPDES Permits

A general NPDES permit is written to cover a category of point sources with similar characteristics for a defined geographic area. The majority of CAFOs may appropriately be covered under an NPDES general permit because CAFOs generally involve similar types of operations, require the same kinds of effluent limitations and permit conditions, and discharge the same types of pollutants.

Individual NPDES permits may be most appropriate for CAFOs that are exceptionally large operations, that are undergoing significant expansion, that have historical compliance problems, and/or that have significant environmental concerns. Individual permits will generally include all of the permit conditions contained in the general NPDES permit as well as some additional requirements. Additional requirements could include liners and covers for manure and wastewater storage units and more frequent water quality monitoring.

5. Relationship to Existing NPDES Permits

EPA expects that most CAFOs will be subject to a general, rather than an individual, permit that requires compliance with the baseline effluent guidelines requirements. If a CAFO decides to pursue voluntary performance standards based on a treatment technology that allows a discharge, EPA expects the permit authority would require the CAFO to prepare and submit an application for an individual NPDES permit. The application will include general information about the CAFO (e.g., ownership, responsible persons, location, receiving stream), waste characteristics, information about the treatment system including design and operational parameters, and expected effluent quality from the proposed treatment system. A CAFO may not discharge from the alternative treatment system until the permitting authority has issued a NPDES permit that allows the discharge.

C. Step-By-Step Requirements for Participation in the Voluntary Performance Standards Program

The voluntary performance standards program has two main requirements: the CAFO must estimate the pollutant discharge associated with the baseline system, and must demonstrate that the alternative treatment technology achieves an equivalent or better reduction in the quantity of pollutants discharged from the production area. This section provides detailed recommendations for how these showings should be made, along with a description of the information that must be submitted to the permitting authority to obtain alternative performance standards.

1. Determining Baseline Pollutant Discharge

If a CAFO decides to participate in the voluntary performance standards program, the CAFO must conduct a technical analysis to estimate the pollutant discharge

Technical Analysis of Discharge

§412.31(a)(2) ...The technical analysis of the discharge of pollutants must include:
(A) All daily *inputs* to the storage system, including manure, litter, all process waste waters, direct precipitation, and runoff.
(B) All daily *outputs* from the storage system, including losses due to evaporation, sludge removal, and the removal of waste water for use on cropland at the CAFO or transport off
site.
(C) A calculation determining the predicted median annual overflow volume based on a 25-year period of actual rainfall data applicable to the site.
(D) Site-specific pollutant data, including N, P, BOD_5, TSS, for the CAFO from representative sampling and analysis of all sources of input to the storage system, or other appropriate pollutant data.
(E) Predicted annual average discharge of pollutants, expressed where appropriate as a mass discharge on a daily basis (lbs/day), and
calculated considering paragraphs (a)(2)(i)(A) through (a)(2)(i)(D) of this section.

associated with the baseline[1] waste management system (e.g., anaerobic treatment lagoon). At a minimum, the technical analysis must include the information in the text box at right (see 40 CFR 412.31(a)(2)).

In an expected limited number of circumstances, the calculated median annual overflow volume based on a 25-year period of actual rainfall data may be zero. In these instances, the permit authority may allow the CAFO to calculate an average overflow volume for the 25-year period.

One approach for estimating pollutant discharges is to use a computer simulation model, spreadsheet, or similar program. One can either develop a new model or revise an existing model that estimates pollutant discharges from waste management systems. These models can be used to evaluate site-specific climate and wastewater characterization data to project the pollutant discharge from your baseline system. The model should evaluate the daily inputs to the waste management system, including all manure, litter, all process wastewaters, direct precipitation, and runoff. The model should also evaluate the daily outputs from the waste management system, including losses due to evaporation, sludge removal, and the removal of wastewater for use on cropland at the CAFO or transported off site. CAFOs may use the model to predict the median annual overflow from the storage system that would occur over a 25-year period. Next, the CAFO should use these overflow predictions, combined with representative pollutant concentrations in the overflow, to predict the annual average discharge of pollutants (including nitrogen, phosphorus, BOD_5, and total suspended solids) over the 25 years evaluated by the model. See 40 CFR 412.31 (a)(2)(i)(E) for the complete list.

Site-specific information that a CAFO should gather and input to the model to calculate the predicted annual discharge of pollutants from the baseline system includes the following (also see 40 CFR 412.31(a)(2)):

- Data on actual local precipitation from the past 25 years. Precipitation data are available from the National Weather Service and possibly a local airport. One can also obtain local precipitation data from EPA's Better Assessment Science Integrating point and Nonpoint Sources (BASINS) model at: http://www.epa.gov/OST/BASINS/b3webwn.htm. State weather data are located at: http://www.epa.gov/ost/ftp/basins/wdm_data/. Historical weather may also be obtained from National Climate Data Center.

- Soil type and permeability in drylot areas. Site-specific soil permeability data may be obtained from the local Soil Conservation District office.

- The rate of evaporation from the storage system (e.g., lagoon, pond, holding tank). Evaporation rate data are available from the National Weather Service or EPA's BASINS model website.

- The concentration of BOD_5, total nitrogen, total phosphorous, suspended solids, and other pollutants as required by the Director, measured in a representative sample collected from the waste management system.

[1]Recall a baseline system at the CAFO is a system that meets the requirements as described in Chapter 2 (see 40 CFR 412.31(a)(1)).

- Starting volume in the waste management system based on process wastes and runoff collected since the last land application or waste management system pump-out and/or sludge clean-out;
- Projected total design storage volume to store manure, wastewater, and other wastes accumulated during the storage period as reflected by the design storage volume (see Chapter 2 of this document);
- Change in the waste management system's volume due to the estimated daily flow of process wastes;
- Change in the storage system volume due to direct precipitation and evaporation;
- Change in the storage system volume due to runoff from open lot areas; and
- Change in volume due to waste management system pump-out and/or sludge cleanout and land application.

The model should calculate the net change in the volume of the liquid storage area daily and add it to the previous day's total. If the total volume is greater than the maximum design volume, then the excess volume overflows. Also, CAFOs can calculate the mass pollutant discharge from the overflow by multiplying the overflow by the pollutant concentration (BOD_5, total nitrogen, total phosphorous, total solids) measured in the representative sample.

Examples 1 and 2 at this end of this chapter present the results of a technical analysis conducted for an example dairy and swine CAFO, representatively. Appendix P provides step-by-step example calculations showing the methodology used to predict the median annual overflow volumes and annual average discharge of pollutants for Examples 1 and 2.

2. Demonstrating That an Alternative Control Technology Achieves Equivalent or Better Pollutant Reductions

EPA recommends that CAFOs follow the steps shown below to demonstrate that an alternative control technology will achieve equivalent or better pollutant reductions:

- Measuring volume or quantity of manure, wastewater, and runoff generation from production areas.
- Collecting samples of manure, wastewater, and runoff to determine raw or untreated pollutant concentrations for treatment system design using the same pollutant parameters as measured for baseline.
- Preparing a conceptual design of the treatment system showing equipment sizing, operational requirements, and expected pollutant reductions by each treatment step.
- Estimating the volume and frequency of discharge from the treatment system.
- Estimating or measuring the concentration of the effluent from the treatment system.

- Results of pilot testing to verify the treatment system will achieve equivalent or better pollutant reductions than baseline for all required constituents (including BOD_5, total nitrogen, total phosphorous, and suspended solids), and to gather information for design of the full scale treatment system. Any pilot testing needs to be related to representative/typical production and climate conditions expected at the CAFO. Therefore, multiple testing episodes or sites may be necessary to adequately capture the actual conditions at the CAFO. Consider on-site pilot testing to demonstrate the proposed system will work at the CAFO.

Examples 1 and 2 summarize the methods that could be used by the example CAFOs to determine if an alternative treatment system performed equivalent or better than the baseline system. In these examples, the permit authority would require the CAFO to continue to collect testing data until the alternative technology has been proven at the site. Thereafter, the CAFO may only need to collect samples frequently enough to demonstrate compliance with their NPDES permit limitations.

Can a CAFO Demonstrate Equivalency Using Practices Already in Existence at the Site?

Yes. If the practices already in place at the operation provide equivalent or better pollutant reductions than the predicted average annual pollutant discharge for the baseline requirements, then the CAFO can apply for an alternative performance standard. Example 3 shows how data from an existing pollution prevention/treatment system were compared to the baseline system to develop site-specific permit limits for an egg production facility.

3. <u>Obtaining an Alternative Performance Standard</u>

The next step in participating in the voluntary performance standards program is to submit an application to the permitting authority along with the technical analyses, conceptual design, results of any pilot-scale testing and any other relevant data before construction of the full-scale treatment system. The permitting authority should review the application, technical analyses, and conceptual design, and then compare the pilot-scale testing results with the predicted annual average discharge of pollutants to verify the proposed treatment system is reasonable, appropriate, and will likely achieve the predicted results. In addition, the permit authority should confirm the quantity of pollutants discharged from the production area are equal to or less than the quantity of pollutants discharged under baseline. The Director has the discretion to request additional information to supplement the CAFO's application, including inspection of the CAFO (40 CFR 412.31(a)(2)(E)(ii)). Once an application is approved, a CAFO can proceed with detailed design and construction of the alternative control technology. Following construction of the treatment system but prior to start-up (see 40 CFR 412.31(a)(3)), the CAFO must obtain an NPDES permit specifying the discharge limitations. Also see section B.4 of this chapter.

Example 1: Whole Milk Dairy, Lancaster, PA

Background

Amish Country Dairy (ACD) is a Large CAFO located in Lancaster County, PA. ACD currently milks 1,200 dairy cows per day, plus manages 400 heifers and 400 calves. Milk cows are confined in a

Example 1: Whole Milk Dairy, Lancaster, PA

550,000 square foot area containing 3 free-stall barns, the a milking parlor, and yard. Free-stall barn alleys are cleaned 3 times per day (every 8 hours) using a flush system. Sawdust is used for bedding in the free stall barn. Silage is kept covered. All flush water, cow wash-water, and parlor cleanup and sanitation water is directed to the existing 3,351,252 cubic foot manure holding lagoon.

All liquids in the holding lagoon are applied to crop land four times each year consistent with the site's NMP. Thus the lagoon has 90 days of storage capacity. To help show the storage structure has adequate capacity, ACD assumes that the storage volume is never less than the accumulated sludge volume plus the minimum treatment volume. Although solids are periodically removed and thus more volume is available to store process wastewater, runoff, and precipitation, this conservative assumption reserves the sludge volume for the maximum amount of accumulated solids over the storage period.

Approximately 40 percent of the milk cow confinement area is paved or roofed. Precipitation from roofed areas drains on to the paved portion of the milk cow confinement area before being discharged to the manure holding lagoon. All paved areas have curbing to contain manure and precipitation. Unpaved areas have reception pits to collect manure and precipitation before discharge to the manure holding lagoon. Heifers and calves are managed on a non-paved 300,000 square foot dry lot that discharges to the manure holding lagoon. Any overflows from the lagoon may eventually reach a receiving surface water body (in this case, the Susquehanna River).

<u>Summary of Baseline Overflow Volume and Pollutant Loading Calculations</u>

Process Wastewater Generation:	25,857 ft^3/day (193,400 gal/day)
Sludge Volume (constant):	870,807 ft^3
Minimum Treatment Volume (constant):	1,530,000 ft^3
Total Existing Storage Lagoon Volume:	3,351,252 ft^3 (25 million gallons)
Volume in Lagoon at Start:	2,400,807 ft^3 (Sludge Volume + Minimum Treatment Volume)
Precipitation Volume (median):	40 in/yr
Evaporation Rate (median):	57 in/yr
Runoff (median):	17,033 ft^3/yr
Liquid/Solids Removal for Crop Application:	Completely dewater all lagoon liquids 4 times per year

Calculated Baseline Overflow Volume Method:

Daily accumulation of lagoon liquids (ft^3/day) =	Process Waste (ft^3/day) + Runoff (ft^3/day) + ((Precipitation - Evaporation (ft/day)) x Lagoon Surface Area (ft^2)
Volume of Lagoon Liquids (ft^3) =	Previous days volume (ft^3) + Accumulation volume (ft^3/day)

Example 1: Whole Milk Dairy, Lancaster, PA

If the Volume of Lagoon Liquids (ft3) is greater than the following:
Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)], then

Overflow Volume = Volume of Lagoon Liquids (ft^3) - [Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)]; and

Volume of Lagoon Liquids (ft^3) is adjusted to the following:
[Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)] (the maximum volume of liquids the lagoon can store)

If it is a land application day:

The Volume of Lagoon Liquids (ft^3) = 0

Model Calculated Overflow Volume for ACD: 57,386 ft^3/yr (429,247 gal/yr)

ACD collected a representative sample of liquid from the storage lagoon to calculate the annual pollutant discharge of BOD_5, total nitrogen, total phosphorous, and total suspended solids (TSS) as a result of the overflow volume. The sample was collected from the top 12 inches of the lagoon surface since the majority of overflow will likely be attributed to this zone. The sampling results are shown below:

BOD_5:	600 mg/L	(5.0 lbs per 1000 gallons)
Total nitrogen:	268 mg/L	(2.2 lbs per 1000 gallons)
Total phosphorous:	208 mg/L	(1.7 lbs per 1000 gallons)
TSS:	1,500 mg/L	(12.5 lbs per 1000 gallons)

Based on the overflow and the measured concentration, the annual pollutant discharges from the lagoon were calculated by multiplying the flow by the concentration as shown in the example for BOD_5 below:

$$BOD_5 : 600 \text{ mg/L} \times 3.785 \text{ L/gal} \times 429,247 \text{ gal/yr} \times 2.2 \text{ lbs/kg} \times 1 \text{ kg}/10^6 \text{ mg} = 2,145 \text{ lbs/yr}$$

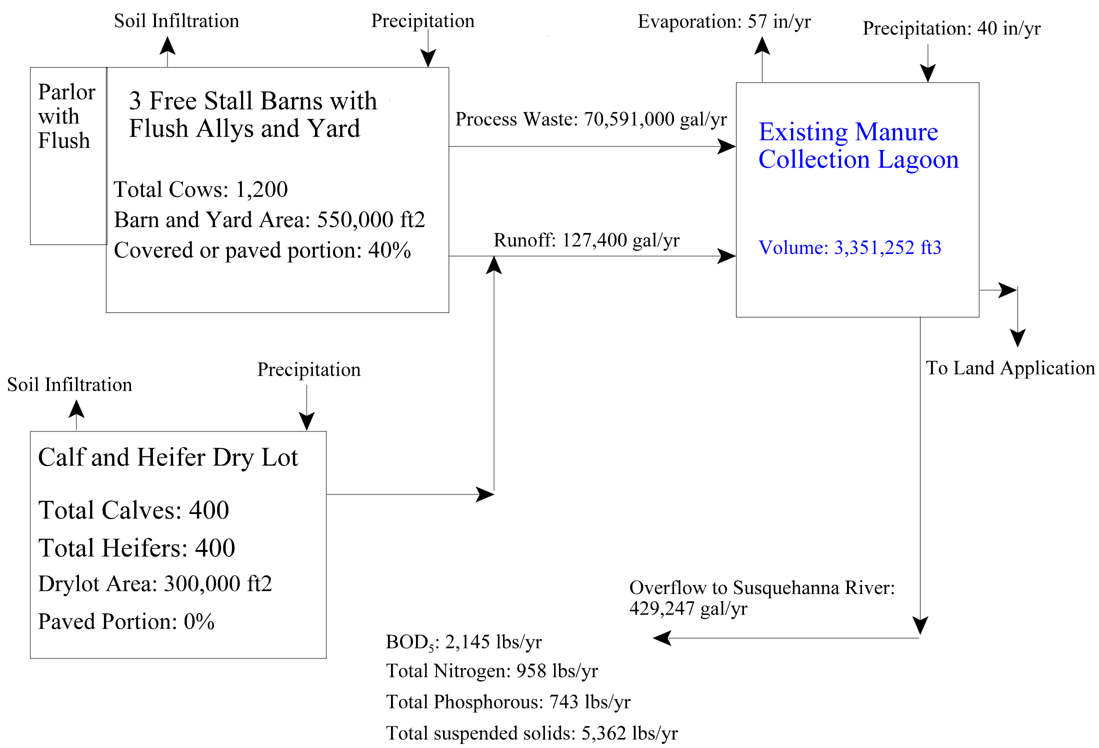
A summary of the pollutant loadings based on the overflow rate and concentration is shown below.

BOD_5	2,145 lbs/yr
Total nitrogen	958 lbs/yr
Total phosphorous	743 lbs/yr
TSS	5,362 lbs/yr

Diagram of Baseline Waste Management System

The following figure is a block diagram of ACD summarizing the inputs and outputs from the manure storage lagoon and the overflows and pollutant loadings. Any overflows from the lagoon eventually reach a surface water body (in this case, the Susquehanna River).

Example 1: Whole Milk Dairy, Lancaster, PA



Waste Characterization and Alternative Treatment System Evaluation

ACD in cooperation with their consultant, Tick Engineering, has decided to voluntarily pursue an alternative to their existing lagoon in order to have a constant discharge of treated water to the Susquehanna River. The treatment train they have selected consists of primary clarification, aerobic biological treatment and final polishing using an engineered wetland. Pilot scale testing of the system was conducted June 15 to November 15 at ACD by Tick Engineering using actual process wastewater. A summary of the conceptual design calculations and pilot scale treatment test results are included below.

<u>Waste Flow and Characterization</u>

A daily composite sample of manure, flush-water, wash-water, parlor cleanup and sanitation water and rainwater was collected by Tick Engineering during a seven day operational period in April 2003 to characterize the waste load discharged to the storage lagoon. The combined volume of manure, flush-water, wash-water, parlor cleanup water and rainwater was also measured during the seven day sampling period in April, 2003. The average daily flow to the lagoon, which included one day of rainfall was 176,410 gallons. Waste characterization data and calculated average daily loading to the treatment system is summarized below:

Example 1: Whole Milk Dairy, Lancaster, PA

Pollutant	Concentration (mg/L)	Influent (lbs/day)
BOD_5	1,701	2,496
Total nitrogen	478	702
Total phosphorous	74	109
TSS	12,269	18,018

Daily pollutant loadings were calculated by multiplying the concentration for each constituent by the average daily flow as shown in the example below for BOD_5:

BOD_5 Loading: 1,701 mg/L x 3.785 L/gal x 1 kg/1,000,000 mg x 2.2 lbs/kg x 176,410 gal/day = 2,496 lbs/day

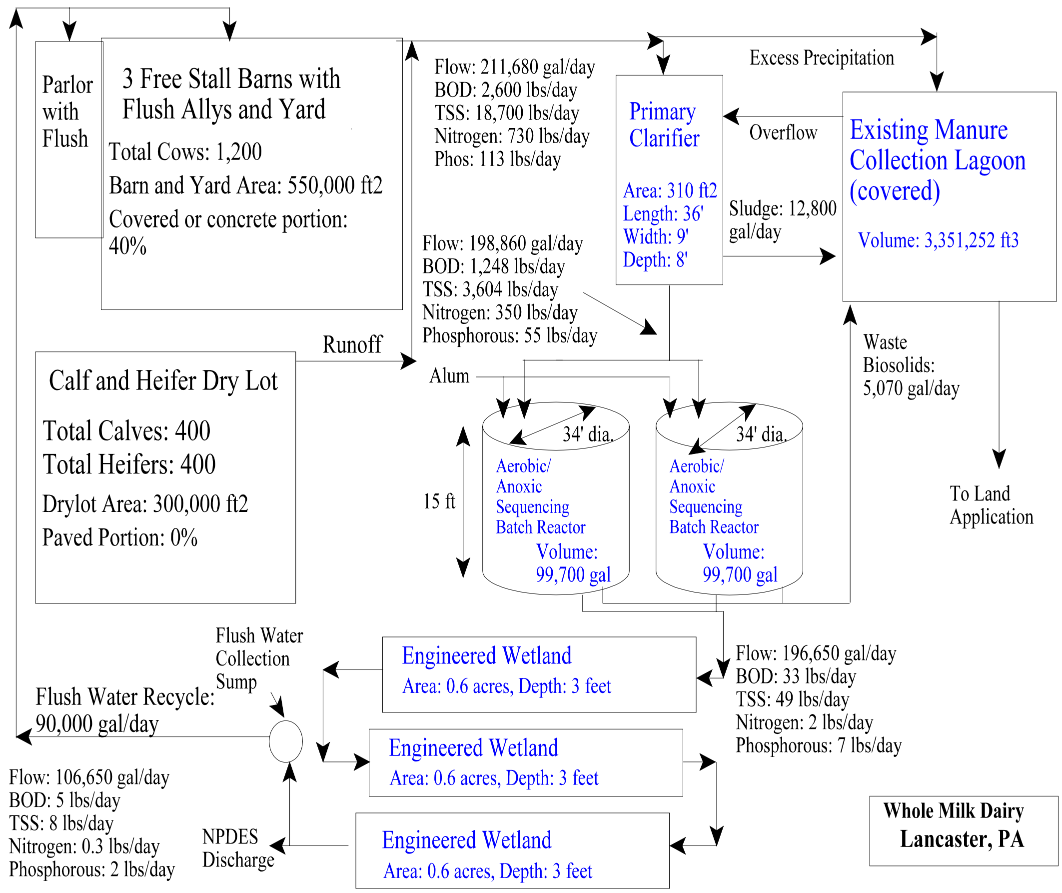
Treatment system design is based on a flow excess of 20% or 211,690 gallons per day. Flows greater than 211,690 gal/day will overflow back to the existing 3,351,252 cubic foot lagoon. During dry weather periods, excess water and direct precipitation from the lagoon will be pumped back to the beginning of the treatment system for processing. The following figure is a flow diagram showing the treatment equipment and sizes, flows in and out of each treatment unit, and the pollutant reductions by each treatment step. Note that ACD will have the capability of recycling nearly 90,000 gallons per day of treated effluent for manure flushing.

Alternative Treatment System Effectiveness

The average concentration of target pollutants measured in the effluent from the pilot scale treatment system during the 6-month study is shown below. The calculated monthly loadings for the full-scale treatment system is based on an average daily flow of 176,410 gallons entering the treatment system minus a recycle flow of 90,000 gallons per day for manure flushing.

Example 1: Whole Milk Dairy, Lancaster, PA

Diagram of Alternative Treatment System



Comparison of the Baseline Overflow to the Discharge from the Alternative Treatment System

Pollutant	Baseline Overflow (lbs/yr)	Treatment System Discharge (lbs/yr)
BOD_5	2,145	1,830
Total nitrogen	958	110
Total phosphorous	743	730
TSS	5,362	2,920

Conclusion: The loadings comparison clearly shows the proposed treatment system consisting of primary clarification, aerobic biological treatment and final polishing using an engineered wetlands would achieve a quantity of pollutants discharged from the production area that is equal to or less than the quantity of pollutants that would be discharged using baseline treatment. Note this analysis pertains to the technology-based requirements of the CAFO rules, and does not include an assessment of whether such a discharge would meet the State's water quality standards.

Example 2: KF Pork Producers, Dubuque, IA

Background

KF Pork Producers (KFP) is a Large CAFO located in Dubuque County, Iowa. KFP currently has 7,000 grower swine with an average weight of approximately 140 pounds. Swine are housed in a 57,400 square foot barn with 10 confinement pens. Manure is washed from pens daily using a flush system. All manure and flush water drains into storage tanks beneath the partially slotted concrete floor. Storage tanks are emptied daily by pumping the manure and flush water to an existing 3,931,800 cubic foot manure holding lagoon.

KFP, in consultation with local residents, avoids de-watering the storage structure on weekends and holidays. Liquids in the holding lagoon are applied to crop land (to the maximum daily hydraulic loading) on the 7th, 14th, 21st, and 28th days of each month during the freeze free period between April 21 and September 14, assuming that there has been no significant precipitation during the three days prior to the day of application. [The nutrient applications are tracked by KFP's Nutrient Management Plan, and are not further considered here.] KFP assumes that the storage volume is never less than the accumulated sludge volume plus the minimum treatment volume. Although there are times that solids are removed and more space is available for process wastewater, runoff, and precipitation, this conservative assumption reserves storage space for the maximum amount of accumulated solids over the storage period.

Summary of Baseline Overflow Volume and Pollutant Loading Calculations

Process waste generation:	8,356 ft^3/day (62,500 gal/day)
Sludge Volume (constant):	486,091 ft^3 (3.6 million gal)
Minimum Treatment Volume (constant):	661,500 ft^3 (4.9 million gal)
Total existing storage lagoon volume:	3,931,800 ft^3 (29.4 million gal)
Volume of Liquids and Solids in Lagoon at Start:	1,206,083 ft^3 (Sludge Volume + Minimum Treatment Volume + Accumulated Process Wastes Since Last Liquid Application)
Precipitation Volume (average):	26 in/yr
Evaporation Rate (average):	98 in/yr
Liquid/Solids Removal for Crop Application:	Land apply lagoon liquids to the maximum hydraulic loading of the crop land on days 7, 14, 21, and 28 of each month unless there has been precipitation in the past three days before the application day (This occurs between the freeze free days between April 21 and September 14)

Calculated Baseline Overflow Volume Method

Daily accumulation of lagoon liquids (ft^3/day) = Process Waste (ft^3/day) + [Precipitation - Evaporation] (ft/day) x Lagoon Surface Area (ft^2)

Example 2: KF Pork Producers, Dubuque, IA

Volume of Lagoon Liquids (ft^3) = Volume of Lagoon Liquids from Previous Day (ft^3) + Daily accumulation of lagoon liquids (ft^3)

If the Volume of Lagoon Liquids (ft^3) is greater than the following:
Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)], then

Overflow Volume = Volume of Lagoon Liquids (ft^3) - [Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)]; and

Volume of Lagoon Liquids (ft^3) is adjusted to the following:
[Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)] (the maximum volume of liquids the lagoon can store)

If it is an application day (day 7, 14, 21, or 28 of the time period between April 21 and September 14), the Volume of Lagoon Liquids (ft^3) = Volume of Lagoon Liquids (ft^3) - Max Hydraulic Loading (ft^3)

Model Calculated Overflow Volume for KFP: 158,419 ft^3/yr (1,184,970 gal/yr)

KFP collected a representative sample of liquid from the storage lagoon to calculate the annual pollutant discharge of BOD_5, total nitrogen, total phosphorous, and total suspended solids (TSS) as a result of the overflow volume. The sample was collected from the top 12 inches of the lagoon surface since the majority of overflow will likely be attributed to this zone. The sampling results are shown below:

$BOD_{5:}$	1,650 mg/L
Total nitrogen:	270 mg/L
Total phosphorus:	102 mg/L
TSS:	3,000 mg/L

Based on the overflow and the measured concentration, the annual pollutant discharges from the lagoon were calculated by multiplying the flow by the concentration as shown in the example for BOD_5 below:

$$BOD_5 : 1650 \text{ mg/L} \times 3.785 \text{ L/gal} \times 1{,}184{,}970 \text{ gal/yr} \times 2.2 \text{ lbs/kg} \times 1 \text{ kg}/10^6 \text{ mg} = 16{,}280 \text{ lbs/yr}$$

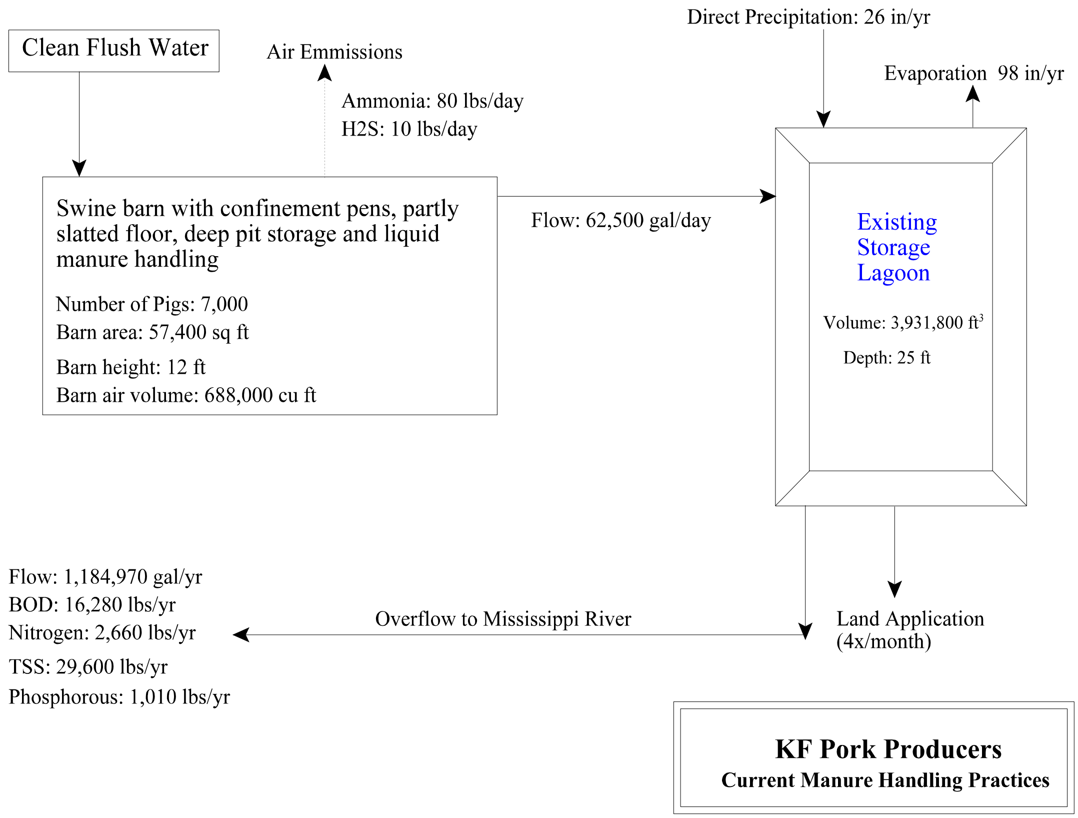
A summary of the pollutant loadings based on the overflow rate and concentration is shown below.

$BOD_{5:}$	16,280 lbs/yr
Total nitrogen:	2,660 lbs/yr
Total phosphorus:	1,010 lbs/yr
TSS:	29,600 lbs/yr

Diagram of Baseline Waste Management System

The following figure is a block diagram of KFP summarizing the inputs and outputs from the manure storage lagoon and the overflows and pollutant loadings. Any overflows from the lagoon discharge to a surface water body (in this case, the Mississippi River).

Example 2: KF Pork Producers, Dubuque, IA



Waste Characterization and Treatment System Evaluation

KFP realized it was not cost effective to haul excess nutrients in the liquid manure. KFP, in cooperation with their consultant WB Engineering, conducted a whole-farm audit to determine if pollutant releases could be reduced at the facility by application of new technologies. WB Engineering examined discharges of pollutants from lagoon overflows, estimated air emissions of ammonia and hydrogen sulfide, and worked with KFP to determine if changes in swine feed rations could lower the amount of ammonia and phosphorous entering the manure. Finally, WB examined manure application rates to determine if more frequent removals of manure/sludge from the lagoon could provide additional storage capacity and less frequent overflows.

As a result of the whole-farm audit, KFP decided to further evaluate a new wastewater treatment system plus an off-gas treatment system for air removed from both the swine barn and manure pits. Changes in feed rations were not implemented on recommendations from both an animal nutritionist and the local agricultural extension agent, and additional application rates of manure to KFP’s crop land would have exceeded nutrient requirements according to the facilities NMP.

The treatment train selected for KFP consists of primary clarification, a vibrating membrane filtration system, and final polishing using a biological trickling filter. For off-gas from the swine barn and manure pits, a biofilter using an inorganic media was selected to remove ammonia and hydrogen sulfide. Pilot scale testing of both the wastewater and air treatment system was conducted March 20 to September 20 2003 by WB Engineering. A summary of the conceptual design calculations and pilot scale treatment test results are included below.

Example 2: KF Pork Producers, Dubuque, IA

Waste Flow and Characterization

A daily composite sample of manure and flush-water was collected by WB Engineering during a seven day operational period in March 2003 to characterize the waste load discharged to the storage lagoon. The volume of manure and flush-water was also measured during the seven day sampling period in April, 2003. The average daily flow to the lagoon was 62,500 gallons. Waste characterization data and calculated average daily loading to the treatment system for the target pollutants is summarized below:

Pollutant	Concentration (mg/L)	Influent (lbs/day)
BOD_5	3,766	1,960
Total nitrogen	753	392
Total phosphorus	301	157
TSS	11,863	6,174

Daily pollutant loadings were calculated by multiplying the concentration for each constituent by the average daily flow as shown in the example below for BOD_5:

BOD_5 Loading: 3,766mg/L x 3.785 L/gal x 1 kg/1,000,000 mg x 2.2 lbs/kg x 62,500 gal/day = 1,960 lbs/day

The wastewater treatment system design is based on a flow excess of 20% or gallons per day. Flows greater than 75,000 gal/day will overflow to the existing 1,500,000 cubic foot lagoon. During dry weather periods, excess water from the lagoon will be pumped back to the beginning of the treatment system for processing. Note that KF will have the capability of recycling nearly 22,600 gallons per day of treated effluent for manure flushing.

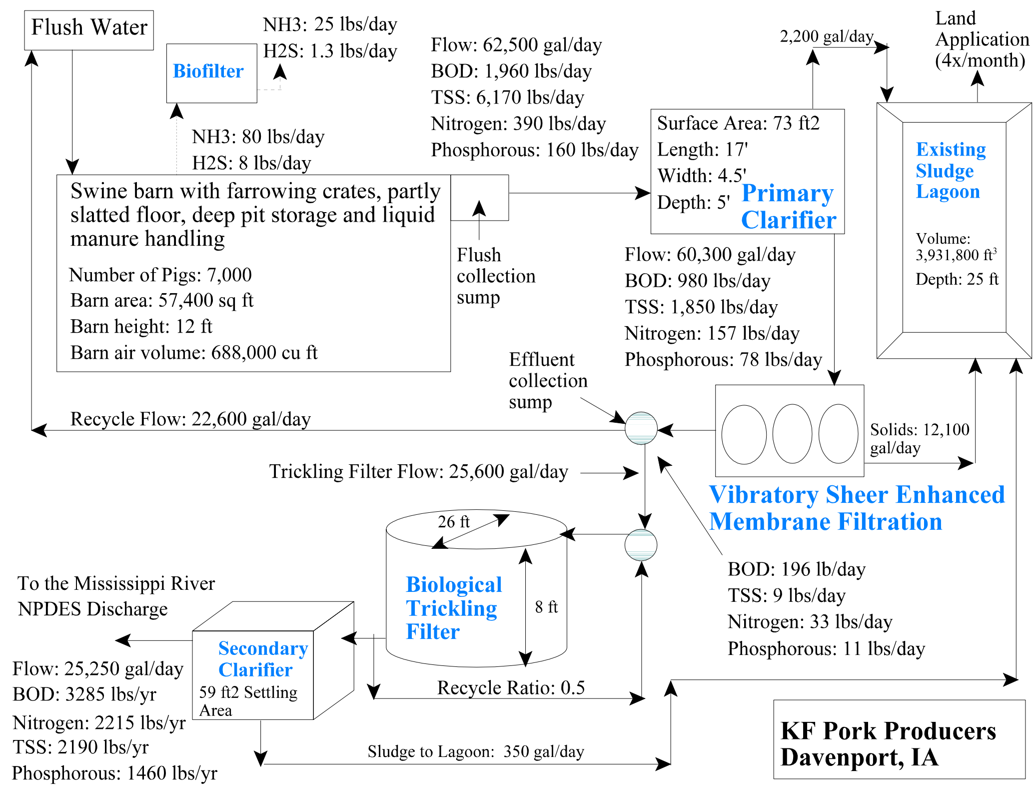
Off-gas from the swine barn and deep pit areas was characterized by collecting air samples from areas near the exit fans. The average concentration of ammonia and hydrogen sulfide measured in the off-gas was 54 ppm and 4 ppm, respectively. Based on a measured exhaust rate from all the exit fans for the barn and pit areas, WB engineering estimates approximately 80 lbs/day of ammonia and approximately 10 lbs/day of hydrogen sulfide is emitted to the atmosphere. Design of the biofilter for treatment of off-gas was provided by BIOREM and consisted of new fans and duct work to move air through a single discharge point, and an in-ground biofilter to destroy ammonia and hydrogen sulfide.

Treatment System Effectiveness

The average concentration of target pollutants measured in the effluent from the pilot scale wastewater treatment system during the 6-month study is shown in the table below. The calculated monthly loadings for the full-scale treatment system is based on an average daily flow of 25,250 gallons. The remaining 37,750 gallons of water that entered the treatment system is used for either recycle or contains concentrated treatment residuals that are discharged to the existing storage lagoon. KFP now has the additional flexibility to collect solids and concentrated nutrients from the existing sludge lagoon and haul them offsite for other uses.

Example 2: KF Pork Producers, Dubuque, IA

Diagram of Alternative Treatment System



Comparison of the Baseline Overflow to the Discharge from the Alternative Treatment System

Pollutant	Baseline Overflow (lbs/yr)	Treatment System Discharge (lbs/yr)
BOD_5	16,280	3,285
Total nitrogen	2,664	2,215
Total phosphorous	1,006	1,460
TSS	29,602	2,190

The average concentration of ammonia and hydrogen sulfide measured in the off-gas from the biofilter during the 6 month pilot scale treatment test is shown below. The biofilter removed approximately 70 percent of the ammonia and 87 percent of the hydrogen sulfide in the gas stream. The biofilter also eliminated all odors from the swine CAFO's offgas.

Biofilter Treatment Results During the 6-Month Pilot Test

Pollutant	Influent Loading (lbs/day)	Gas Flow (cfm)	Effluent Loading (lbs/day)	Odor
Ammonia	80	23,000	25	None
Hydrogen Sulfide	10	23,000	1.3	None

Example 2: KF Pork Producers, Dubuque, IA

Conclusion: Comparison of the pilot scale testing results with the calculated overflow discharges indicates the proposed treatment system can not achieve a quantity of pollutants discharged for all the targeted pollutants that is equal to or less than the quantity of pollutants that would be discharged under the baseline performance standards. Because the proposed treatment system cannot achieve this reduction for all target pollutants, the permitting authority denies the facility's request for an individual NPDES permit for operation and discharge of water from the proposed treatment system. If modifications to the treatment system can be made that lower the annual discharge of phosphorous, then an individual permit may be considered.

KF Pork Producers has still decided to install a new biofilter system to remove odors, ammonia and hydrogen sulfide from their air stream to address complaints from neighbors regarding smells from the facility.

Example 3: Birvan Egg Farms, Okeechobee County, FL

Background

Birvan Egg Farms (Birvan) is a Large CAFO located Okeechobee County, Florida. Birvan currently has 40,000 laying hens with an average weight of approximately 3 pounds. Birds are housed in a high-rise cage system. Manure drops from the cages to the floor below and is picked up by the wet flush system and is transferred to the anaerobic digester. The anaerobic digester removes the majority of nutrients, BOD_5 and volatile solids while generating methane that is used in the facilities boiler system. Effluent from the anaerobic digester is pumped through a vibrating membrane filtration system for polishing residual solids, BOD_5 and nutrients before land application of the polished water to a small grass field. All solids are hauled and sold off-site. Birvan elected to install an anaerobic treatment system rather than a holding pond due to space constraints and the lack of crop land to apply liquids and solids. The manure treatment system has been in operation since 1996.

Birvan calculated the overflow volume and loading from a baseline system (a liquid storage structure) that could have been installed at the facility and compared the results with the loadings currently being obtained from the existing treatment system.

Summary of Baseline Overflow Volume and Pollutant Loading Calculations

Estimated Storage Lagoon Volume if Constructed:	58,200 ft3 (435 thousand gallons)
Process Waste Generation:	374 ft^3/day (2,800 gal/day)
Volume of Liquids and Solids in Lagoon at Start:	635 ft^3 (Sludge Volume + Minimum Treatment Volume + Accumulated Process Wastes Since Last Liquid Application)
Precipitation Volume (average):	61 in/yr
Evaporation Rate (average):	90 in/yr
Sludge Volume (constant):	5,900 ft^3
Minimum Treatment Volume (constant):	9,200 ft^3
Assumed removal rate:	2x per month from January 21 to December 9

Example 3: Birvan Egg Farms, Okeechobee County, FL

Calculated Baseline Overflow Volume Method:

Daily accumulation of lagoon liquids (ft^3/day) = Process Waste (ft^3/day) + [Precipitation - Evaporation (ft/day)] x Lagoon Surface Area (ft^2)

Volume of Lagoon Liquids (ft^3) = Previous days volume (ft^3) + Accumulation volume (ft^3/day)

If the Volume of Lagoon Liquids (ft3) is greater than the following:
Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)], then

Overflow Volume = Volume of Lagoon Liquids (ft^3) - [Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)]; and

Volume of Lagoon Liquids (ft^3) is adjusted to the following:
[Existing Storage Lagoon Volume (ft^3) - Sludge Volume (ft^3) - Minimum Treatment Volume (ft^3)] (the maximum volume of liquids the lagoon can store)

Model Calculated Overflow Volume for Birvan: 3,162 ft^3/yr (23,651 gal/yr)

Birvan collected a representative sample of liquid from the digester to calculate the annual loading of BOD_5, total nitrogen, total phosphorous, and total suspended solids (TSS) that would be discharged as a result of the overflow volume. The sample was collected from the top 12 inches of the digester surface since the majority of overflows will likely be attributed to this zone. The sampling results are shown below:

$BOD_{5:}$	1,500 mg/L
Total nitrogen:	750 mg/L
Total phosphorus:	100 mg/L
TSS:	3,200 mg/L

Based on the overflow and the measured concentration, the annual pollutant discharges from the storage system was calculated by multiplying the flow by the concentration as shown in the example for BOD_5 below:

$$BOD_5: 1500 \text{ mg/L} \times 3.785 \text{ L/gal} \times 23{,}651 \text{ gal/yr} \times 2.2 \text{ lbs/kg} \times 1 \text{ kg}/10^6 \text{ mg} = 295 \text{ lbs/yr}$$

A summary of the pollutant loadings based on the overflow rate and concentration is shown below.

$BOD_{5:}$	295 lbs/yr
Total nitrogen:	148 lbs/yr
Total phosphorus:	20 lbs/yr
TSS:	433 lbs/yr

Treatment System Evaluation

Birvan has been collecting monthly samples for BOD_5, total nitrogen, total phosphorous, and total suspended solids from the existing treatment system since early 1997. The measured monthly concentrations in the treatment system effluent and the total flow through the treatment system over the past 12 months is shown below.

Example 3: Birvan Egg Farms, Okeechobee County, FL

Measured Treatment System Effluent Concentration and Total Influent Flow During the Past 12 Months

Month	BOD_5 (mg/L)	Nitrogen (mg/L)	Phosphorous (mg/L)	TSS (mg/L)	Total Flow (gal)
June	20	3.3	0.6	14	83,800
July	21	5.2	0.8	15	83,200
August	13	1.6	0.7	10	84,600
September	8	0.8	0.6	9	83,900
October	9	0.6	0.4	7	84,200
November	18	3.5	0.6	13	84,700
December	13	2	0.7	11	84,300
January	6	0.7	0.4	9	82,900
February	8	0.7	0.4	8	83,900
March	19	1.8	0.8	13	84,700
April	20	4.2	1.2	15	85,100
May	7	2.7	0.8	14	84,300
Median	**13**	**1.9**	**0.6**	**12**	**84,250**

As shown in the figure below, the vibrating membrane filter generates a concentrated waste stream equaling 20% of the influent flow (16,850 gal/month). This concentrated waste stream is sent to a 10,000 gallon holding tank prior to off-site shipment. Effluent from the vibrating membrane filter enters a lift station where submersible pumps transfer approximately 45,000 gallons per month back to the layer house for manure flushing. Based on a measured average flow rate of approximately 22,400 gallons per month at Outfall 001 and the concentration of pollutants in the vibrating membrane treatment system effluent, the following annual loadings to St. Lucie Canal were calculated and compared to the baseline overflow loadings.

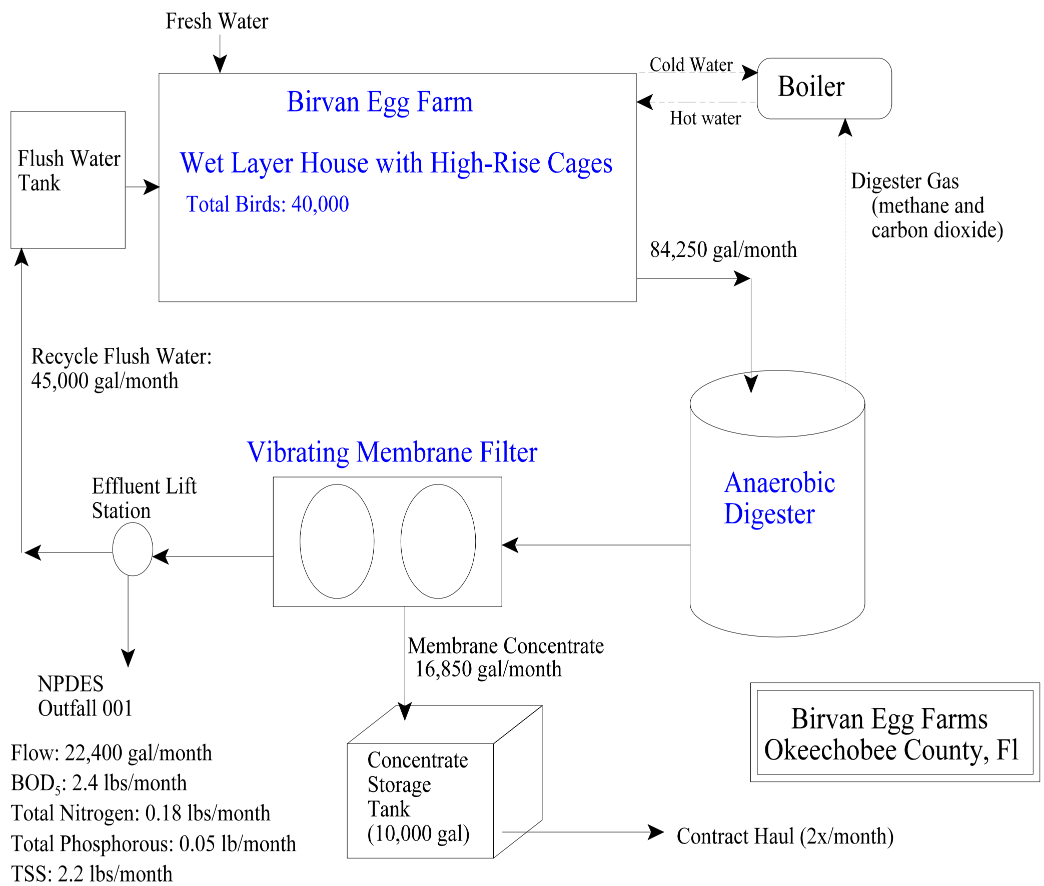
Comparison of the Calculated Baseline Overflow Discharge to the Treatment System Discharge

Pollutant	Baseline Overflow (lbs/yr)	Treatment System Discharge (lbs/yr)
BOD_5	295	29
Total nitrogen	148	4.2
Total phosphorous	20	1.3
TSS	433	27

Conclusion: The comparison shows that the existing treatment systems consisting of an anaerobic digester and vibrating membrane filtration system achieves better performance than the baseline system for all targeted pollutants. If water quality constraints for fecal coliform in the St. Lucie canal make additional treatment necessary, Birvan is also considering increasing the temperature of the digester to make it thermophilic, a practice known to reduce fecal coliform in the effluent.

Example 3: Birvan Egg Farms, Okeechobee County, FL

Diagram of Existing Treatment System



4. <u>Future Case Studies</u>

EPA may provide additional case studies in the future, such as examples of whole-farm multi-media evaluations, voluntary alternative standards as applied to silage leachate, or alternative technologies for handling mortalities. Additional suggestions and recommendations may be sent to EPA at the address provided in Chapter 1 of this document.

CHAPTER 6: DEVELOPING AND USING TECHNICAL STANDARDS FOR THE LAND APPLICATION OF MANURE, LITTER, AND PROCESS WASTEWATER

The CAFO effluent guidelines require Large CAFOs to develop and use site-specific nutrient application practices that are in compliance with the technical standards for nutrient management established by their permitting authority. Permitting authorities establish technical standards to minimize phosphorus and nitrogen transport to surface water. The effluent guidelines call for technical standards that establish methods and criteria for determining application rates that balance the nutrient needs of crops with the potential adverse impacts on water quality.

This chapter provides guidance on how permitting authorities may establish technical standards and other land application considerations. This chapter also presents *Manure Management Planner* as a resource for Nutrient Management Plan (NMP) development, some example calculations for determining land application rates, and NMP case studies using *Manure Management Planner*.

A. Developing Technical Standards for Land Application

Technical standards for the land application of manure, litter, and/or process wastewater must include a field-specific assessment of the potential for nitrogen and phosphorus transport from the field to waters of the U.S. In addition, the standards must address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to waters of the U.S. To develop technical standards for land application, permitting authorities may use the NRCS *Nutrient Management Conservation Practice Standard*, Code 590, (see Section A.4 of this chapter) or other appropriate technical standards as guidance. It should be noted, however, that consistency with NRCS Code 590 may not by itself ensure compliance with the regulatory requirements for technical standards for nutrient management (see 40 CFR 123.36)

1. <u>EPA Recommended Technical Standards and Policies</u>

EPA has developed a "National Nutrient Management Technical Standard" to guide the permit authority (regions and states) in developing and using technical standards. The "National Nutrient Management Technical Standard" is provided in Appendix O. The purposes of the technical standards are to enable agricultural users of nutrients to:

- Minimize pollution of surface and ground water resources from agricultural nutrient sources;
- Budget and supply nutrients for plant production;
- Properly use manure, litter, process wastewater, and/or other organic by-products as a plant nutrient source;

Nutrient Management Definition

Planned process to protect water quality by managing the amount, source, placement, form, and timing of agricultural wastes and soil amendments utilized for the production of crop, forage, fiber, and forest products. It is supplying essential nutrients in adequate amounts to balance and maintain the soil for healthy biology and quality plants while avoiding conditions inimical to the ecosystem.

- Maintain or improve the physical, chemical, and biological condition of the soil; and

- Prevent or reduce excess nutrient concentrations in the soil.

This chapter describes how the content of NMPs are based on the technical standards, including the field risk assessment, determination of land management units, nutrient application rate development, nutrient application timing and methods, areas of special consideration, and operation and maintenance practices. This chapter also provides additional recommendations for sampling (e.g., soil, plant tissue, manure and process wastewater) and guidelines for laboratory analyses.

The Field Risk Assessment

CAFOs must perform field-specific risk assessments to determine whether manure nutrients should be applied at a nitrogen or phosphorus application rate, or whether land application should be avoided under state technical standards. CAFOs must use the state-approved method. Currently, most states have adopted one of the three field risk assessments defined in the NRCS *Nutrient Management* standards. The three field risk assessments defined in the NRCS *Nutrient Management* standards are: 1) Phosphorus Index; 2) Soil Phosphorus Threshold Level; and 3) Soil Test Phosphorus Level.

In some instances phosphorus levels in soils are so high, or site-specific conditions (e.g., highly erodible soils) are such that any application of manure, litter, or process wastewaters would be inconsistent with appropriate agricultural utilization of nutrients. Such instances would lead to excessive levels of nutrients and other pollutants in runoff. EPA expects that these factors will be taken into account as state permitting authorities develop appropriate technical standards for the land application of manure by CAFOs.

To reduce a field-specific risk, CAFOs may apply conservation practices, best management practices, or management activities to their land application areas to reduce nutrient transport to surface waters. For example, a CAFO may be able to implement the conservation plan components of a CNMP to a field to reduce the field's risk rating, often resulting in increased flexibility to land apply manure.

Responsibilities

The CAFO rules require the permit authority to develop the technical standards for nutrient management. Large CAFOs have, under their permits, a responsibility to develop their NMP to meet the state technical standards and other requirements.

In developing NPDES permits, permit writers use the effluent guidelines, NPDES CAFO rule, and the technical standards for nutrient management. Development of the NPDES permit and how technical standards affect permits is discussed in EPA's *NPDES Permit Writer's Guidance Manual and Example NPDES Permit for Concentrated Animal Feeding Operations* (EPA-833-B-04-001). The NPDES regulations provide that the permitting authority must establish technical standards for nutrient management that are consistent with the requirements in 40 CFR 412.4(c)(2) (also see 40 CFR 123.36). The permitting authority must include in the technical standard, at a minimum, the methodologies necessary to address the following components of a NMP:

- Field-specific assessment of the potential for nitrogen and phosphorus transport from the field to waters of the U.S.;
- Form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to waters of the U.S.; and
- Appropriate flexibility for CAFOs to implement the standard (e.g., multi-year phosphorus banking, 40 CFR 412.4(c)(2)(ii)).

EPA strongly encourages states to address water quality protection issues when establishing technical standards (i.e., appropriate land application practices). EPA expects that state and Tribal technical standards for nutrient management will be developed collaboratively among the respective state departments of agriculture, Tribes, NRCS state conservationists, state Land Grant Universities, and NPDES permitting authorities.

Coordination/Communication to Develop Technical Standards and NMPs

EPA expects that permitting authorities will provide guidance to CAFOs on how to implement the state technical standards, in coordination with their state agricultural agency partners. In addition, EPA believes that a well-prepared Comprehensive Nutrient Management Plan (CNMP) prepared in accordance with the CNMP Technical Guidance issued by USDA's NRCS should in most instances help the CAFO meet the NMP and minimum practice requirements of the permit, including the requirement to comply with the state technical standards (although whether a CNMP is adequate to meet these requirements is ultimately judged on a case-by-case basis).

CAFO owners and operators should seek technical assistance for developing NMPs from integrators, industry associations, and private consultants. In addition, federal agencies, such as the NRCS, as well as state and Tribal agricultural and conservation agency staff, Cooperative Extension Service agents and specialists, Soil and Water Conservation Districts, and Land Grant Universities may be able to provide technical assistance. A number of computer-based tools are being developed to facilitate the development and implementation of NMPs. For example, see *CNMP Watch* at http://www.cnmpwatch.com/ , a web site of the National Association of State Departments of Agriculture (NASDA) Research Foundation, for an update on nutrient management planning.

Nutrient Management Planning Tools

Many states, universities, and private sector companies have developed nutrient management tools that can be used (generally within a specific state) to assist livestock and poultry producers develop site-specific nutrient management plans. One example of such tools is *Manure Management Planner (MMP*), developed at Purdue University. This is a manure utilization planning tool to help develop nutrient management plans. Access MMP at http://www.agry.purdue.edu/mmp/.

NMPs are complex documents that require knowledge in a number of different areas. Therefore, CAFO personnel should undergo general nutrient management training to understand plan components and to successfully implement the plan. Free training, which lasts between one and four days, is often available from state agricultural Cooperative Extension Offices.

The CAFO rules do not require the use of a certified specialist to develop a NMP; however, EPA encourages CAFOs to use certified planners with expertise to develop, modify, or review their NMPs. See Chapter 4 of this document for more information.

2. Factors for Developing Technical Standards

Technical standards should be developed to consider various factors for CAFOs, such as site-specific production data, watershed and jurisdictional boundaries, local environmental issues, and climate and natural resources. Permitting authorities should develop land application technical standards to address the types of crops grown, number of animals at the CAFO, nutrient concentrations in the manure, and other nutrient sources.

CAFOs may be subject to multiple technical standards if located near watershed or jurisdictional boundaries. For example, the permitting authority may develop stricter technical standards for an impaired water body. CAFOs should work with their permitting authority to determine the applicable technical standards.

Different regions of the country may need to review specific environmental issues for their area. States may develop different technical standards for urbanized vs. rural areas. Stricter technical standards may be applied to CAFOs located near impaired watersheds (e.g., the Chesapeake Bay, Gulf of Mexico).

The climate and natural resources of an area directly affect the land application of manure, litter, and process wastewater. When permitting authorities develop the technical standards (and when CAFOs develop their NMP), factors they should consider include type of soil, air quality issues that may affect management practices, and health issues (e.g., high levels of heavy metals or pathogens in the manure). For example, CAFOs located west of the Mississippi River tend to have water deficient and calcareous soils, while CAFOs located east of the Mississippi River tend to have water excess and acidic soils.

3. NRCS Standards and NMPs

Many technical standards for nutrient management have already been developed as part of implementing USDA's National Nutrient Management policy. NRCS developed a national *Nutrient Management Conservation Practice Standard* (Code 590) that serves as a basis for each state NRCS office to develop its own tailored standard. Almost all States have developed a Phosphorus Index as part of their states' *Nutrient Management Conservation Practice Standard* (Code 590). EPA expects that in most cases States have relied or will rely on these NRCS standards to form the basis for the technical standards established by the permitting authority.

The USDA's CNMP guidance contains six key elements: 1) manure and wastewater handling and storage; 2) nutrient management; 3) land treatment practices; 4) recordkeeping; 5) feed management; and 6) other manure and wastewater use options. As discussed in Chapter 4 of this document, EPA endorses the CNMP approach but cautions CAFOs that following USDA's CNMP Guidance does not guarantee that a CAFO's CNMP will adequately address all of the minimum elements that are required by the regulations for a nutrient management plan.

See the *Permit Writers Guidance* for a comparison of USDA's CNMP six elements and EPA's minimum measures.

The NRCS web site provides technical guidance to develop NMPs including a national template at http://www.nrcs.usda.gov/technical/references/. NRCS and EPA permitting authorities may have different definitions and requirements for nutrient management plans. Therefore, to meet the requirements for a NMP that complies with state technical standards, CAFOs may need to modify the elements of current NMPs or NMPs developed using NRCS standards. Appendix C includes a checklist that CAFOs may use to help ensure all requirements have been addressed in the NMP.

4. Example National Nutrient Management Technical Standards for Land Application

EPA has developed a "National Nutrient Management Technical Standard," set forth in Appendix O. EPA intends to apply this example technical standard in states where EPA is the permitting authority. States may use this technical standard as guidance in developing state technical standards for land application.

In those States where EPA is the permitting authority and required to establish the technical standards for nutrient management, this guidance recommends the use of the EPA Example Technical Standard in conjunction with the State's conservation practice for nutrient management (590) for this purpose. Upon review of the State's 590, any missing items required by the CAFO rules must be included in the terms and conditions of the NPDES permit.

Example State Technical Standards for Winter Applications

When frozen soils prevent effective incorporation of nutrients at the time of application do not apply nutrients:
(a) within Surface Water Quality Management Areas (1,000 feet of lakes, or within 300 feet of perennial streams). Identify perennial streams using the NRCS soil survey and/or USGS 1:24,000 scale topographic map.
(b) within 200 feet upslope of wells, sinkholes, fractured bedrock at the surface, or gravel pits identified by the planner.
(c) on slopes greater than 9%, except for manure on slopes up to 12% with concentrated flow channels maintained in permanent vegetative cover. Slopes from 9% to 12% must be either contour stripcropped with alternate strips in perennial forage or contour farmed where all of the residue from the previous corn crop (harvested for grain) remains on the soil surface. Areas that do not contribute runoff to surface water or groundwater conduits may be exempted based on an in-field evaluation. Do not apply any nutrients on slopes greater than 12%.

5. Appropriate Flexibility in Applying Technical Standards

State regulations (including technical standards) may be more restrictive than the federal CAFO regulations. For example, the state may establish the specific conditions and criteria applicable to winter spreading of manure.

The permitting authority and CAFO should look at the appropriateness of certain requirements in the technical standards in how they apply at that site. Examples include practicality of manure, litter, and process wastewater storage, allocation, and application; equipment calibration and limitations; accessibility of records (e.g., feed management component of NMP with integrator-supplied feed); and available data (e.g., crop, soil, or feed information). In developing the technical standards, the permitting authority shall also include appropriate flexibility for any CAFO to implement nutrient management practices to comply with the technical standards, as described above.

B. Example Rate Calculations

Large CAFOs must use the technical standards developed by the permitting authority to write a NMP. Chapter 4 of this manual discusses the aspects of the NMP in more detail. This section provides examples for calculating application rates. To properly manage manure, litter, and process wastewater, CAFOs must determine amount of manure produced, manure composition, nutrient requirements for crops, and the appropriate application rate (nitrogen-based or phosphorus-based). Throughout this section, an example dairy farm will be used to demonstrate the calculations. These examples are for illustrative purposes only.

1. Manure Production and Composition

To develop appropriate manure application rates, CAFOs must estimate the amount and composition of manure, litter, and process wastewater available for land application. The amount of manure generated at a CAFO is directly linked to the number of animals maintained. However, because the composition of manure changes as it ages, the amount collected and applied to the land is often much less than the amount generated by the animals. Therefore, CAFOs should estimate the amount of manure that will be available for land application by calculating the volume of manure, litter, and process wastewater stored on site and/or by calculating the quantity of manure removed during cleaning times.

Because the nutrient content of manure depends on many site-specific practices, CAFOs may **NOT** use book values of manure to develop NMPs. CAFOs must sample the site manure at least annually and should send the samples to an accredited laboratory for analyses of at least total nitrogen (N) and phosphorus (P). Because it is a primary essential element for plant growth, CAFOs should also sample for potassium (K). See Chapter 4, Section A.2 and Appendix E of this manual for further details on manure sampling.

Example: Calculations for a Dairy Farm

Site Description

The Dairy Farm houses approximately 800 cows on site annually. The average herd/flock size includes 500 lactating cows, 150 heifers, 100 dry cows, and 50 calves.

The Dairy Farm uses a waste storage lagoon to store process wastewater (liquid wastes) from the milking center and flush barns, runoff from the feedlot, and direct precipitation into the lagoon. The farm treats wastewater from the milking center and flush barns in a solid/liquid separator prior to discharge into the storage lagoon. The site uses a concrete slab to store solid manure and litter wastes from the dry lot, barns, and solid/liquid separator.

Calculating the Amount of Manure Produced and Collected Annually

Solid Manure: The Dairy Farm collects solid manure from the barns where the dry cows and heifers are housed and the dry lot where the calves are housed. By weighing the front-end loader before and after a load of manure is removed from the dry lot, the site calculates that approximately 8,000 pounds of manure are collected weekly. The manure is then transferred to a concrete slab for

Example: Calculations for a Dairy Farm

storage until land application.

In addition, the liquid/solids separator generates 31,000 pounds of solids daily. This quantity is also calculated by weighing the front-end loader before and after removing the solids.

The annual collection of manure solids is calculated from the following equation:

Solid Manure = (8,000 lbs/week x 52 weeks/year) + (31,000 lbs/day x 365 days/year)
= 11,731,000 lbs/year ÷ 2000 lbs/ton
= 5,865 tons/year

Calculating the Amount of Manure Produced and Collected Annually (Continued)

Liquid Manure: Process wastewater collected and stored in the waste storage pond consists of flush water from the milking center (parlor, holding area, and milk room); flush water from the freestall barns where the milking cows are housed; runoff from the feedlot; and direct precipitation. An estimated total of 6.6 million gallons per year of liquid manure is produced at the operation. The following calculations are used to estimate the quantity of liquid manure produced and collected at The Dairy Farm.

Milking Center - The Dairy Farm estimates approximately 30 gallons of cleaning water is used per lactating cow each day.

= 30 gallons/cow/day x 500 lactating cows
= 15,000 gallons/day x 365 days/yr
= 5,475,000 gallons/yr

Flush Barns - Most of the water used to flush the freestall barns is recycled from the lagoon. However, one day's worth of flushing water (approximately 100 gallons per cow) is included in the total liquid waste as part of the lagoon's design capacity. Only lactating cows, dry cows, and heifers are included in this calculation; the calves are kept on dry lots.

= 100 gallons/cow/day x 750 lactating and dry cows
= 75,000 gallons/yr

Runoff - The runoff collection area totals 15 acres. The annual precipitation is approximately 5 inches, with 40% runoff from the dry lot.

= 15 acres x 43,560 square feet/acre x (5 inches/yr ÷12 inches/feet) x 40%
= 108,900 cubic feet/year

Conversion to gallons:
= 108,900 cubic feet/year x 7.48 gallons/cubic feet
= 814,572 gallons/year

Direct Precipitation - The size of the lagoon is 200 feet by 425 feet and the annual precipitation is 5 inches.
= (5 inches/year ÷ 12 inches/feet) x 200 feet x 425 feet
= 35,417 cubic feet/year

Conversion to gallons:
= 35,417 cubic feet/year x 7.48 gallons/cubic feet
= 264,919 gallons/year

Example: Calculations for a Dairy Farm

Total Liquid Manure	=	(5,475,000 + 75,000 + 814,572 + 264,919) gallons/year
	=	6,629,500 gallons/year

The total amount of manure, litter, and process wastewater produced annually is 5,865 tons of solids and 6.6 million gallons of liquids.

Manure Sampling Analysis

Solid Manure Sampling - The Dairy Farm samples the manure stored on the concrete slab using a hand-made sampling device (similar to a soil auger). The sampling includes collecting six random samples from wastes stored on the slab and mixing all six samples together.

Liquid Manure Sampling - The Dairy Farm samples the waste storage lagoon using a plastic cup attached to a long pole. The sampling includes collecting eight random samples from around the shoreline of the lagoon and mixing all eight samples together.

Manure Sampling Results

Solid Manure: Total Kjedahl Nitrogen (TKN) - 9 pounds/ton
Total Phosphorus - 3 pounds/ton
Potassium - 6 pounds/ton
pH - 7.4

Liquid Manure: Total Kjedahl Nitrogen (TKN) - 12 pounds/1,000 gallons
Total Phosphorus - 6 pounds/1,000 gallons
Potassium - 10 pounds/1,000 gallons
pH - 7.5

2. Developing a Nutrient Budget

CAFOs must estimate the nutrient requirements of the soils where manure, litter, and process wastewater will be land applied. This includes sampling the soil, planning of the crops, and recommended crop nutrient requirements. The recommended nutrient requirements are generally provided by the local Cooperative Extension Office and based on planned crops, expected crop yields, and current soil test results.

Example: Calculations for a Dairy Farm

Site Description

The Dairy Farm owns and operates a total of 400 acres; 375 acres of cropland and 25 acres for the dairy operation. No land is currently rented. The Dairy Farm uses two fields for land application: 1) Field 1 with 250 acres; and 2) Field 2 with 125 acres.

Example: Calculations for a Dairy Farm

Soil Sampling

The soils of both fields used for land application are sampled separately. The results of the samples are below.

Field 1:
- Nitrogen - 20 pounds/acre
- Phosphorus - 75 pounds/acre
- Potassium - 90 pounds/acre
- pH - 6.2
- Soil Organic Matter: 2.2%

Field 2:
- Nitrogen - 25 pounds/acre
- Phosphorus - 110 pounds/acre
- Potassium - 110 pounds/acre
- pH - 5.8
- Soil Organic Matter: 2.6%

For Field 1, the phosphorus concentration is not high (defined as greater than 100 pounds per acre according to the state technical standards); therefore, the land application rate of manure may be up to and including the nitrogen-based rate. For Field 2, the phosphorus concentration is "high" (i.e., >100 pounds/acre); therefore, the land application rate of manure must be no greater than the phosphorus-based rate.

Crop Yields

The crop production history for the previous five years is used to estimate crop yields.

Field Number	Year	Crop	Crop Yield (tons/acre)
1	199920002001	Alfalfa	556
1	20022003	Corn-silage	2022
1	20022003	Winter wheat	34
2	199920002001	Corn-silage	232120
2	20022003	Alfalfa	55

Example: Calculations for a Dairy Farm

The Dairy Farm plans to plant corn-silage in both fields in April 2004 (harvested September 2004) and winter wheat in both fields in September 2004 (harvested December 2004). The expected crop yield is calculated using the average historical crop yield:

Field 1, Corn-silage Yield Estimate = (20 tons/acre + 22 tons/acre)/2
= 21 tons/acre

Field 1, Winter Wheat Yield Estimate = (3 tons/acre + 4 tons/acre)/2
= 3 tons/acre

Example: Calculations for a Dairy Farm

Field 2, Corn-silage Yield Estimate = (23 tons/acre + 21 tons/acre + 20 tons/acre)/3
= 21 tons/acre

Field 2, Winter Wheat Yield Estimate: use 3 tons/acre since no crop yield history data are available.

Recommended Crop Nutrient Requirements

The Dairy Farm uses information from the local Cooperative Extension Office, expected crop yields, and soil test results to determine recommended crop nutrient requirements.

Field Number	Crop	Nutrient Requirements (Nitrogen)	Nutrient Requirements (Phosphorus)
1	Corn-silage	180 pounds/acre	20 pounds/acre
1	Winter wheat	40 pounds/acre	30 pounds/acre
2	Corn-silage	180 pounds/acre	20 pounds/acre
2	Winter wheat	40 pounds/acre	30 pounds/acre

Example: Calculations for a Dairy Farm

Nutrient Credits

Nutrient credits for nitrogen include previous legume crops, residual nitrogen from previous manure applications, nitrogen from irrigation water, and other sources. Field 1 planting did not include a legume crop the previous year, therefore there is no nitrogen credit for legume crops. The Dairy Farm applied manure at a rate of 100 pounds of nitrogen per acre for the past two years. The residual nitrogen is calculated by multiplying the mineralization factor by the manure application rate for the previous years. The following mineralization factors, obtained from the local Cooperative Extension Office, are used for the calculation: 12% for one year ago and 5% for two years ago.

Residual Nitrogen = 0.12 x 100 lb/acre + 0.05 x 100 lb/acre
= 17 lb/acre

The Dairy Farm will apply a starter commercial fertilizer to Field 1 prior to planting the corn-silage, resulting in a nitrogen credit of 10 pounds per acre. Based on tests of the irrigation water performed by the county, only a very small concentration of nutrients are present in the water. This nitrogen concentration is assumed negligible. The local Cooperative Extension Office did not identify any other nutrient credits.

Total Nitrogen (N) Credit for Field 1 = 0 (legume crop) + 17 lb/acre (residual N) + 10 lb/acre (fertilizer) + 0 (irrigation water) + 0 (other sources)

= 7 lb nitrogen/acre

Example: Calculations for a Dairy Farm

Field 2 has no phosphorus nutrient credits.

3. Land Application Rate Calculation

Using the recommended crop nutrient requirements and nutrient credits, CAFOs can calculate the land application rate of manure, litter, and process wastewater. Land applications are typically either nitrogen-based or phosphorus-based. See Chapter 4, Section B.6 for more details. In the example below, if the phosphorus concentration in the soil is "high" (as indicated by laboratory results), or the PI rating is "high", the CAFO would use a phosphorus-based application rate.

Example: Calculations for a Dairy Farm

Field 1 Nitrogen-Based Land Application Rate

Field 1 land application will be nitrogen-based. The amount of nitrogen in the manure available to the crops during the first year of application (Plant Available Nitrogen, PAN) is 5 pounds per ton of solid manure and 5.8 pounds per 1,000 gallons of liquid manure. The following equation is used to estimate the manure application rate of nitrogen.

Manure Application Rate = Recommended Crop Nutrient Requirements - Nutrient Credits

Field 1, Corn-silage = 180 lb/acre - 27 lb/acre
= 153 lb/acre

Field 1, Winter Wheat = 40 lb/acre - 27 lb/acre
= 13 lb/acre

The Dairy Farm will apply liquid manure to Field 1 at the following rates:

Liquid Manure Application Rate (Field 1, Corn-silage) = 153 lb/acre ÷ 5.8 lb PAN/1,000 gallons
= 26,380 gallons/acre

Liquid Manure Application Rate (Field 1, Winter wheat) = 13 lb/acre ÷ 5.8 lb PAN/1,000 gallons
= 2,240 gallons/acre

Field 2 Phosphorus-Based Land Application Rate

Field 2 land application will be phosphorus-based. The Dairy Farm assumes that 100% of the phosphorus in the manure will be available to the plants. The following equation is used to estimate the manure application rate of phosphorus.

Manure Application Rate = Recommended Crop Nutrient Requirements - Nutrient Credits

Field 2, Corn-silage = 20 lb/acre - 0 lb/acre
= 20 lb/acre

Example: Calculations for a Dairy Farm

Field 2, Winter Wheat = 30 lb/acre - 0 lb/acre
= 30 lb/acre

The Dairy Farm will apply solid manure to Field 2 at the following rates:

Solid Manure Application Rate (Field 2, Corn-silage) = 20 lb P/acre ÷ 3.0 lb P/ton
= 6.7 tons/acre

Solid Manure Application Rate (Field 2, Winter wheat) = 30 lb P/acre ÷ 3.0 lb P/ton
= 10 tons/acre

C. Manure Management Planner

As far as NMP tools go, the Manure Management Planner (MMP) is probably one of the most efficient and comprehensive planning tools to use. MMP is nationally

Manure Management Planner

Developed at Purdue University, MMP is a Windows-based computer program that is used to create manure management plans for crop and animal feeding operations. The user enters information about the operation's fields, crops, manure storage, animals, and application equipment. MMP helps the user allocate manure (where, when and how much) on a monthly basis for the length of the plan (1-10 years). This allocation process helps determine if the current operation has sufficient crop acreage, seasonal land availability, manure storage capacity, and application equipment to manage the manure produced in an environmentally responsible manner. The planner can use the program with the CAFO manager to determine the most efficient utilization of manure in iterative processes, allowing the CAFO/farm manager to determine not only how and where to utilize manure, but also how to revise their own plans of crop rotation to maximize nutrient uptake and long-term land application. MMP is also useful for identifying changes that may be needed for a non-sustainable operation to become sustainable, and determining what changes may be needed to keep an operation sustainable if the operation expands.

supported by both EPA[1] and USDA-NRCS for nutrient management planning. MMP automatically calculates Extension fertilizer recommendations and manure nutrient availability automatically in accordance with state NRCS 590 standards. MMP automatically imports field data from Missouri's Spatial Nutrient Management Planner (SNMP) GIS, which is also supported nationally by EPA for nutrient management planning. MMP can be set to automatically import data from soil test labs and Customer Service Toolkit. MMP currently supports 25 states: AL, AR, DE, FL, GA, IN, IL, IA, KS, MA, MI, MN, MO, MS, MT, NE, ND, NM, OH, OK, PA, SD, TN, UT and WI.

Manure Management Planner (MMP) is freely obtained from www.agry.purdue.edu/mmp. Full technical documentation can be downloaded from www.agry.purdue.edu/mmp/MmpDocs.htm.

SNMP is also free (www.cares.missouri.edu/snmp)

[1]EPA is publishing this information in an effort to further public understanding of how a manure utilization planning tool can be used to develop nutrient management plans that can further efforts to protect our environment. The EPA does not endorse products nor does it recommend for or against the purchase of specific products.

CHAPTER 7: AVOIDING COMMON DEFICIENCIES

Historically, the majority of discharges from CAFOs occur from manure handling systems and during the land application of manure. In most cases, the discharge did not occur during a rainfall event. In many cases, the discharge could have been avoided through better planning, management, and operation of the CAFO. Even though proper operation and maintenance is a standard permit condition, it is often helpful to simply be aware of the types of deficiencies that may ultimately lead to a discharge. This chapter focuses on the more common deficiencies that may lead to permit violations, pollutant discharges, or both, and provides some tools CAFOs may use to avoid such deficiencies.

Disclaimer: The purpose of this chapter is to give examples of practices that could lead to a CAFO being out of compliance with its permit requirements. These examples are not intended to comprehensively describe the CAFO regulatory requirements and the full set of practices that are necessary for a CAFO to remain in compliance. For more information, visit the Agriculture Compliance Assistance Center website at http://www.epa.gov/agriculture/.

A. Proactive Management

Norton et. al. (1996) developed a dual approach of developing management plans and conducting farm inspections for addressing key aspects of pollution risk management: proactive management and reactive management. Proactive management involves identifying the potential for any discharge, assessing what can be done to minimize the risk of discharge, and then taking steps to ensure the potential discharge does not occur. In contrast, reactive management deals with the actions necessary to respond to a discharge and then implementing measures to prevent an incident from reoccurring. Many state spill response plan requirements and the Environmental Management System guidelines for ISO14000 certification (ASQ,1996) require addressing incidents such that they do not recur.

Example: Permit Violations in North Carolina

A review of permit violations on concentrated animal feeding operations in North Carolina found that two hundred eighty-five (285) discharges occurred between 1996 and 2000. Forty-two percent (42%) of discharges from swine facilities were related to the land application of lagoon effluent and thirty-nine percent (39%) were from the manure handling systems. Lagoon liquid levels were observed to be exceeding the lagoon's 25-year, 24-hour storm storage level at over 80% of all visits.

Source: Sheffield, 2002.

Resources are available to help a CAFO to determine an accurate environmental profile for their operation. For example, the National Livestock Producers Association (NLPA) and Environmental Management Solutions, LLC, formed a clearinghouse for the On-Farm Assessment and Environmental Review (OFAER) program. The OFAER Program provides a free, confidential assessment of animal production facilities and is available to the producer through NLPA. The program helps give producers an edge regarding the public's perception of their operation and offers cost savings by taking advantage of a third party's animal production and environmental stewardship knowledge. The OFAER program can help all operations learn what strengths and challenges face the operation, as well as offer helpful recommendations concerning these issues. For more information see http://www.nlpa.org/html/ofaer_program.shtml or contact America's Clean Water Foundation at http://www.acwf.org/projects/ofaer.html for more information on the assessment program and to download the OFAER environmental assistance program's *Form A: Producer Checklist*.

CAFOs may request compliance assistance from EPA's Agriculture Compliance Assistance Center. For more information see http://www.epa.gov/agriculture/.

CAFOs may also contact the state agriculture and environmental agencies for other resources.

B. Common Deficiencies

1. Inadequacy of Storage Capacity

The minimum storage period for livestock and poultry manures is not specifically defined by the CAFO regulations. The NRCS recommends that manure storage facilities have a minimum of 6 months of storage capacity. As discussed in Chapter 2 of this document, a case-by-case evaluation of the appropriateness of the storage period specified in a NMP based on the proposed nutrient utilization strategy is necessary for a balanced assessment of other acceptable storage periods. See Chapter 2 for more information on adequate storage.

2. Infrequent Dewatering of Storage Structures

A well-designed manure storage facility must also be well managed to prevent the development of environmental concerns. Management decisions relative to startup and loading (especially anaerobic lagoons), manure removal, monitoring of structure integrity and other issues, and maintenance of appearance and aesthetics play critical roles in a well-managed storage facilities. Probably the single most important requirement in operating and maintaining a manure storage facility is to ensure that the facility does not overflow or discharge. Discharges from manure storage facilities may violate permit requirements and other state or local regulations; result in large fines or penalties; and, at the very least, represent a potential environmental hazard. Manure removal from storage according to the storage period selected is the most critical activity in preventing discharge. Many discharge problems have occurred because producers were unable to manage the activities necessary to remove manure from storage in a timely manner.

3. Pumpdown Practices

Lagoon effluent and holding pond water is usually removed by pumping equipment similar to irrigation equipment. Hand carry, solid set, stationary big gun, traveling gun, drag-hose systems, and center pivot equipment have all been used to land apply liquids. Experience has shown that unplanned discharges and spills sometimes occur with pumping activities. Sources of such unplanned discharges include burst or ruptured piping, leaking joints, operation of loading pumps past the full point of hauling equipment, and other factors. Hence, pumping activities should be closely monitored, especially in the “startup” phase, to ensure that no spills or discharges occur. Continuous pumping systems such as drag-hose or irrigation systems can be equipped with automatic shut-off devices (which usually sense pressure) to minimize the risk of discharge in the event of pipe failure. In some situations lagoon liquid may be applied through permanent irrigation systems that are used to apply water for crop production. For this type of system backflow/anti-siphon devices should be installed to preclude the chance of contamination of the fresh water supply. All process wastewater pumped out must be accounted for in the overall nutrient balance calculated in the CAFO’s NMP.

4. Lagoon Agitation

Lagoons may or may not be agitated. When they are not agitated, considerable nutrient buildup in the bottom sludge will occur. Agitation is a critical operation in maintaining available storage in liquid manure systems. Some facilities have designed storage structures equipped with pumps to allow wastewater application without additional agitation. Failure to properly agitate will likely result in a continuing buildup of settled solids that are not removed. The result is less and less available storage capacity as time goes by.

Agitation of manure resuspends settled solids and ensures that most or all of the manure will flow to the inlet of the pump or removal device. Additionally, agitation homogenizes the manure mixture and provides a more consistent nutrient analysis as the manure is being land applied. Agitation of manure storage facilities releases gases that may increase odor levels and present a health hazard. Consideration should be given to weather and wind conditions, time of day, and day of the week to minimize the possibility of odor conflicts while agitating. Some CAFOs may be subject to local or state requirements for agitation.

5. Representative Manure Samples

It is inappropriate to sample the more dilute liquid from the top of storage facility, and then agitate the solids during land application activities. If a storage facility will be agitated just prior to or during land application, manure samples for nutrient analysis, in order to be considered representative, should be obtained after the facility is well agitated. In most cases, the results of such an analysis will not be available before land-applying the manure. In these cases, analysis results from the most recent pumping events can be used to anticipate the present analysis (and estimate the proper application rate). The present analysis, when available, can be used to calculate the nutrients actually applied. The CAFO must include this information in the records and address it in the NMP.

6. Animal Mortality Practices

NMPs developed as a condition of an NPDES permit must ensure proper management of typical and catastrophic animal mortalities, as described earlier in this document. It is important for the CAFO also to identify and review any applicable State and local regulations concerning animal mortalities. In many cases, state or local laws and ordinances may prohibit the use of specific animal mortality practices. The plan must comply with any state or local requirements. These regulations can often be found at the State Department of Agriculture of the State Health Department. The permit authority, as well, should take note of any such State or local requirements prior to reviewing a NMP as part of a permit application review or conducting an inspection.

Potential issues concerning compliance with the requirements for handling animal mortality include the following:

- Underestimating the number of mortalities;
- Inappropriate technology selection based on type and number of animals;
- Incorrect sizing of storage and treatment facilities;
- Failure to address catastrophic mortality; and
- Failure to identify or meet state and local requirements.

7. Chemical Handling

CAFOs must ensure that chemicals and other contaminants handled on-site are not disposed of in any manure, litter, process wastewater, or storm water storage or treatment system unless specifically designed to treat such chemicals and other contaminants (40 CFR 122.42(e)(1)). Examples include pesticides, hazardous and toxic chemicals, and petroleum products/by-products. This standard does not impose any new use restrictions that do not already exist. Many chemicals will disrupt the biological treatment processes that may be a part of a CAFO's waste handling and storage system. Any chemicals that enter manure and wastewater storage structures could be discharged to surface water during land application of the manure and wastewater or during spills or other accidental releases.

In general, poor housekeeping is an indicator of improper storage and handling of chemicals and an increased potential for contamination of manure and wastewater structures. The CAFO's NMP should identify where chemicals are stored, where any mixing and loading are conducted, how empty containers and waste materials are disposed of, and what practices are employed to prevent chemicals from inappropriately entering the manure and wastewater storage structures.

In addition, livestock operations may be subject to section 311 of the CWA, which addresses pollution from oil and hazardous substance releases. The regulations established by EPA to implement this portion of the CWA have two sets of requirements — the Spill Prevention

Control and Countermeasures (SPCC) plan rule, and the Facility Response Plan (FRP) rule. Only a very limited number of livestock operations are expected to meet the requirements for having to prepare an SPCC plan and even fewer would need to prepare an FRP. In those cases where the SPCC requirements do apply to a CAFO, it may be appropriate to address these requirements in concert with the chemical handling minimum standard in the NMP. Additional information on the SPCC program can be obtained at EPA's web site at www.epa.gov/oilspill

8. Emergency Action Plans

Behind most manure spills and discharges is a chain of events that leads up to an unsafe act, improper judgment, unsafe conditions, or a combination of factors. Preventing or properly responding to discharges on a farm is everyone's concern. Communication among the farm owner, supervisors, and employees generates ideas and awareness that leads to accident prevention and quick response if a spill does occur. Education programs, response plans, and regular inspections of manure management and application systems are essential links in maintaining a safe, accident-free operation.

Emergency action plans are needed to minimize the environmental impact of manure spills, discharges, or mishaps. In several states, these plans are required to be developed and maintained on all livestock and poultry operations, especially those with liquid manure management systems. This plan would be implemented if manure or other wastes from an operation are leaking, overflowing, or running off the site. Rather than waiting until the manure or wastewater reaches a stream or leaves the property, act preemptively to ensure that this mishap does not happen.

The Emergency Action Plan should be available to all employees, because accidents, leaks, and breaks could happen at any time. The plan should follow this format:

- Eliminate the source;
- Contain the spill, if possible;
- Assess the extent of the spill and note any obvious damage;
- Contact the appropriate agencies; and
- Clean up the spill and make repairs.

In addition, the CAFO may be required to have a closure plan for their manure storage structures or impoundments. See Section 4.2 of the *Permit Guidance* for more information.

9. Example Onsite Check List

NPDES CAFO Permit NMP Nine Minimum Practices Review Checklist

The checklist is composed of three parts which are to be completed as follows:

Part A **Summary Information**
Documents critical information concerning the operation.

Part B **Detailed Plan Review and On-Site Inspection Checklist**
To be completed when reviewing a plan or during an on-site inspection of the operation.

Note: Some of the information in this checklist may only be applicable to Large CAFOs. Please consult regulations for additional details.

Part A - Summary Information

1. Plan Preparer Certification

- Did the plan preparation involve certified technical specialists? ☐ Yes ☐ No
- Are the name and certification credentials of the plan preparer identified in the plan? ☐ Yes ☐ No

2. Type of Operation

- Is the facility operated ☐ Year Round ☐ Seasonally

Notes: ______

- Is the operation ☐ Open lot ☐ Partially enclosed ☐ Fully enclosed.

Notes: ______

- Does the description of the facility in the plan reflect the description of the facility in the application/NOI/Fact Sheet/Permit? ☐ Yes ☐ No

3. Facility Maps

- Does the plan include maps that identify topography, soil types, confinement areas, manure and wastewater storage, raw material storage, handling, and treatment facilities, and environmentally sensitive areas (sinkholes, wells, drinking water sources, field tile drain outlets) for the production area and all land application areas owned or under the ownership, rental, lease, other legal arrangement of the CAFO operator? ☐ Yes ☐ No ✗
- Does the plan identify the watershed(s) in which the operation is located including latitude and longitude to the entrance of the production area? ☐ Yes ☐ No
- Is this watershed listed on the State's list of impaired watersheds? ☐ Yes ☐ No

If yes, what impairments are identified? ______

- Is this facility located in a state designated source water protection area? ☐ Yes ☐ No
- Are there any other water quality problems in this watershed? ☐ Yes ☐ No

Explain: ______

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

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4. Animals

- What type of animals are confined at the facility?

☐ Beef (slaughter/feeder) ☐ Chicken – Layer
☐ Dairy ☐ Chicken – Broiler
☐ Swine ☐ Sheep/lambs
☐ Turkey ☐ Horse
☐ Other ________ ☐ Duck

- What is the design capacity by animal type?

☐ Beef (slaughter/feeder) ____________ ☐ Chicken – Layer ____________
☐ Dairy ____________ ☐ Chicken – Broiler ____________
☐ Swine ____________ ☐ Sheep/lambs ____________
☐ Turkey ____________ ☐ Horse ____________
☐ Other ____________ ☐ Duck ____________

- Is the plan based upon the design capacity? .... ☐ Yes ..... ☐ No

If no, what capacity is the plan based upon? ____________

____

____

- Does the plan identify the size (acres) of the production area? ☐ Yes _____ acres ☐ No

5. Manure/Litter/Process Wastewater Generation

- What are the manure generation rates for N, P, and K identified in the plan?

Animal Type 1 .... N_____ lbs/Year ✘ P_____ lbs/Year ✘ K_____ lbs/Year
Animal Type 2 .... N_____ lbs/Year ✘ P_____ lbs/Year ✘ K_____ lbs/Year
Animal Type 3 .... N_____ lbs/Year ✘ P_____ lbs/Year ✘ K_____ lbs/Year

- What are the manure generation rates for N, P, and K rates based upon?

☐ Current year manure analysis from this operation
☐ Historical manure analysis from this operation [Note Year(s): _______]
☐ Book value [Note Source: ____________]

- Are the generation rates for N, P, and K generally consistent with USDA's Agricultural Waste Management Field Handbook? .... ☐ Yes ..... ☐ No

If no, are other practices in place that account for the rates included in the plan? .... ☐ Yes ..... ☐ No

What are the practices identified in the plan? .... ☐ Feed Management ..... ☐ Other

Explain: ____________

____

____

If no, are atmospheric N losses used in the plan excessive? .... ☐ Yes ..... ☐ No

✘ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

6. Manure Utilization Options

- What manure utilization options are identified in the plan? (*Note if more than one option is identified in the plan indicate the relative amount of the manure/wastewater utilized under this option*)

Land Application .... ☐ Yes ______% ...... ☐ No

If yes: how many acres of land owned or under the control of the applicant are available for applying manure/wastewater generated by the CAFO? ________ acres.

Do the facility maps identify the fields or conservation management units (CMU) used to develop the plan? (Field boundaries, field number, acreage) .... ☐ Yes .... ☐ No ✗

Composting .... ☐ Yes ______% ...... ☐ No

Incineration .... ☐ Yes ______% ...... ☐ No

If yes, does the plan address what is done with the remaining ash ________________

____

____

Other .... ☐ Yes ______% ...... ☐ No

Describe (as needed) ______________________________

____

- Is manure generated at the CAFO sold/given away for use at another location not associated with the generating CAFO? .... ☐ Yes ...... ☐ No

If yes, what is the estimated amount transferred annually? ________ tons

7. Crop Production

- Does the plan identify what crops are produced? .... ☐ Yes ...... ☐ No ✗

What are they? ______________________________

- Does the plan identify the crop rotations (if any)? .... ☐ N/A .... ☐ Yes ...... ☐ No

What is the crop rotation? ______________________________

____

____

- Does the plan identify cropping practices? .... ☐ Yes ...... ☐ No

If yes, what are they? ☐ Ridge Till ☐ Conservation Tillage
☐ Other ______________________________

- Does cropping system use irrigation? .... ☐ Yes ...... ☐ No

If yes, what type. ☐ Flood ☐ Sprinkler
☐ Overland ☐ Center Pivot
☐ Ridge and furrow ☐ Traveling Gun

- Is crop/rotation information provided in the plan for each field/CMU? .... ☐ Yes ...... ☐ No
- Are realistic crop yield goals identified in the plan? .... ☐ Yes ...... ☐ No
- What source of information was used by to determine the realistic yield goals for this operation?

☐ Farm Records (*Circle One:* last year's crop and production, 3-year average, 5-year average)
☐ USDA ☐ State Databases (VALUES, MASCAP)
☐ County Averages ☐ Previous crop insurance records

- Is adequate justification provided to support the yield goal. .... ☐ Yes ...... ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements

8. Nutrient Application

- Does the plan identify the basis/rationale for determining an N-based or P-based application rate? ☐ Yes ☐ No ✗

  What is the basis? ☐ State Regulations/Nutrient Management Technical Standard ☐ NRCS Code 590

  ☐ Other ____________

- Does the plan identify the application method? ☐ Yes ☐ No ✗

  If yes, what method is used: ☐ Surface applied ☐ Injected ☐ Incorporated

- Does the NMP reference the correct State Nutrient Management Technical Standard identified in the permit? ☐ Yes ☐ No ✗
- Does the plan include land application areas that are N-based and others that are P-based? ☐ Yes ☐ No

9. 25-Year, 24-Hour Storm Information*

- Does the plan utilize the correct 25-Year, 24-Hour rainfall amount for the location of this operation to determine storage requirements?* ☐ Yes ☐ No ✗

  Note source of information ____________

Additional Comments: ____________

* Some facilities are required to design storage impoundments based on a 100-year, 24-hour storm.

Part B - Detailed Plan Review and On-Site Inspection Checklist.

Minimum Practice **Ensure Adequate Storage Capacity**

Plan Review

- Does the plan identify the volume and duration of storage required for the facility? ☐ Yes ☐ No ✗
- Does the storage volume in the plan account for manure and process wastewater in addition to the collection of runoff and the 25-year/24-hour storm event for the CAFO location? (Note: New source swine, poultry, and veal operations use a 100-year/24-hour storm) ☐ Yes ☐ No ✗
- Are storage structures constructed and operated in accordance with the ELG? ☐ Yes ☐ No ✗
- Does the plan include a schedule for cleaning out the storage structures or solids removal for liquid storage structures? ☐ Yes ☐ No ✗
- Does the plan require maintenance for all storage structures? ☐ Yes ☐ No ✗

On-Site Inspection

- Is a depth marker in place in all lagoons and other appropriate storage structures? ☐ Yes ☐ No ✗
- Is adequate lagoon storage volume being maintained? ☐ Yes ☐ No ✗
- Is the length of storage documented in on-site records consistent with storage practices identified in the plan? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

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Minimum Practice — Ensure Proper Management of Mortalities

Plan Review

- Is animal mortality addressed in the plan .... ☐ Yes ..... ☐ No ✗

  If yes, what methods are identified in the plan to address animal mortality?
  ☐ Rendering ☐ Incineration ☐ Composting ☐ Disposal pits
  ☐ Landfill ☐ Other ______________

- Does the plan address mortality storage prior to final disposition? .... ☐ Yes ..... ☐ No
- Is the mortality rate used in the plan consistent with USDA expected values for the animals confined at the operation? .... ☐ Yes ..... ☐ No
- Does the animal mortality plan meet State requirements? .... ☐ N/A .... ☐ Yes ..... ☐ No ✗

On-Site Inspection

- Are the animal mortality disposal methods and equipment identified in the plan in place and being properly implemented? .... ☐ Yes ..... ☐ No ✗

Minimum Practice — Divert Clean Water From Production Area

Plan Review

- Does the plan include provisions that address the diversion of clean water from the production areas? .... ☐ Yes ..... ☐ No

  If no why? ____

  ____

  If no, is the runoff being collected and is storage of runoff adequate? (See Minimum Standard No. 8) .... ☐ Yes ..... ☐ No

- Does the plan require periodic visual inspection to verify proper and functional diversion? .... ☐ Yes ..... ☐ No
- Does the plan address the maintenance of diversion structures? .... ☐ Yes ..... ☐ No

On-Site Inspection

- Are the diversion provisions identified in the plan being properly implemented? .... ☐ Yes ..... ☐ No
- Is the storage capacity sufficient for all non-diverted runoff? .... ☐ Yes ..... ☐ No
- Are records of periodic inspections being maintained? .... ☐ Yes ..... ☐ No
- How often are operator inspections being conducted? (*Circle one:* Daily Weekly Monthly)

Minimum Practice — Prevent Direct Contact

Plan Review

- Does the facility or topo map identify any surface water in the production area? .... ☐ Yes ..... ☐ No

  If yes, are measures in the plan to prevent direct contact? .... ☐ Yes ..... ☐ No ✗

  What are the measures identified in the plan? ☐ Fences ☐ Other

On-Site Inspection

- Is there surface water in the production area? .... ☐ Yes ..... ☐ No
- Are the measures identified in the plan being implemented and maintained to prevent direct contact? ☐ Yes ☐ No ✗
- Are there any animals in contact with surface water in the production area? .... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

Minimum Practice **Chemical Handling**

Plan Review

- Has the facility incorporated measures (in accordance with applicable laws and regulations) to prevent the mishandling of pesticides, hazardous and toxic chemicals, and petroleum products/by-products from contaminating manure and wastewater? .... ☐ Yes ..... ☐ No

  If no, explain: ______

On-Site Inspection

- Are the measures identified being implemented? .... ☐ Yes ..... ☐ No
- Is there any evidence of mishandling of pesticides, hazardous and toxic chemicals, and petroleum products/by-products contaminating manure and wastewater storage .... ☐ Yes ..... ☐ No

  Notes: ______

  ______

Minimum Practice **Conservation Practices to Reduce Nutrient Loss**

Plan Review

- Does the plan include the use of best management practices (BMPs) to control runoff from the
  - Production area .... ☐ N/A .... ☐ Yes ..... ☐ No
  - Land application area(s) .... ☐ N/A .... ☐ Yes ..... ☐ No
- Do the plan and facility maps identify the specific areas that the BMPs are to be applied?

Land Application Areas	**Production Area**
☐ Vegetated Buffers (Type of vegetation ______)	☐ (Type of vegetation ______)
☐ Diversion	☐
☐ Grassed Waterway (Type of vegetation ______)	
☐ Strip Cropping	
☐ Residue Management	
☐ Terracing	
☐ Conservation Tillage	

- If any of these BMPs are being used does the plan specify how they are to be implemented? .... ☐ Yes ..... ☐ No

  If yes, what does the plan require? ______

  ______

- What references are cited for the practices? ☐ USDA Practice Standards ☐ State Standards

  ☐ Other ______ *(Note: to be used to verify proper implementation)*

- Does the plan include O&M requirements for practices used to reduce nutrient loss? .... ☐ Yes ..... ☐ No

On-Site Inspection

- Are the nutrient loss minimization practices in the plan being properly implemented? .... ☐ Yes ..... ☐ No ✗
- If buffers are being used, are the widths in agreement with those identified in the plan? .... ☐ Yes ..... ☐ No
- Is there no evidence of buffers being breached by waste? .... ☐ Yes ..... ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

Minimum Practice **Protocols for Manure and Soil Testing**

Plan Review

- Does the plan include specific protocols for the sampling and analysis of manure, wastewater and soil for determining nutrient content? ☐ Yes ☐ No ✗
- Are these protocols recognized by the State or identified in the State Nutrient Management Technical Standard? ☐ Yes ☐ No ✗
- Does the plan identify the sampling frequency for manure and soil sample analysis? ☐ Yes ☐ No ✗

  (At a minimum manure/wastewater samples are to be taken annually and tested for nitrogen and phosphorous and soil samples taken and tested for phosphorous at least once every 5 years.)

On-Site Inspection

- Were the manure/wastewater and soil samples taken within 12 months of developing the site-specific NMP? ☐ Yes ☐ No
- Have manure and soil samples been collected at a frequency that is consistent with permit requirements? ☐ Yes ☐ No ✗
- Are the sampling protocols consistent with permit requirements or those specified in the state nutrient management technical standard? ☐ Yes ☐ No

  (At a minimum manure/wastewater samples are to be taken annually and tested for nitrogen and phosphorous and soil samples taken and tested for phosphorous at least once every 5 years.)
- Are the results of the sample analysis consistent with the content and analyses of the NMP? ☐ Yes ☐ No

Minimum Practice **Protocols for Land Application of Manure and Wastewater**

Plan Review

- What is the number of acres owned/acres leased or subject to an access agreement to be used for land application identified in the plan? ______acres owned ______acres leased ______acres applied
- Does the plan identify weather and soil conditions under which application activities will not be conducted (e.g., frozen ground)? ☐ Yes ☐ No
- Does the plan include a proper analysis to determine whether application rates are to be based upon N or P for each management unit? ☐ Yes ☐ No ✗
- Is the analysis consistent with the State Nutrient Management Technical Standard identified in the permit or approved by the Director of the permitting authority? ☐ Yes ☐ No ✗
- Does the plan take into account other sources of nutrients used at the operation? ☐ Yes ☐ No ✗

  If yes, what other sources of nutrients have been accounted for:

  ☐ Commercial Fertilizer ☐ Biosolids
  ☐ Bedding ☐ Legume Credits
  ☐ Wastewater ☐ Previous manure applications
  ☐ Other ______

- Does the plan include the application of wastewater to fields via an irrigation system? ☐ Yes ☐ No

  If yes:
  → Does the plan identify the type of irrigation system? ☐ Yes ☐ No
  → Are the nutrients contributed by the irrigation system accounted for in the nutrient budget for the operation? ☐ Yes ☐ No
  → Does the plan include provisions to minimize ponding or puddling of wastewater on land application fields? ☐ Yes ☐ No
  → Does the plan address the management of drainage water to prevent surface or ground water contamination? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

- Does the plan identify the crop rotation system, crop nutrient requirements based on soil testing, realistic yield goals*, and crop nutrient removal? ☐ Yes ☐ No ✗
- Does the plan include restrictions or adequate management practices to prevent water pollution from the application of manure/wastewater to flooded, saturated, frozen, or snow covered ground? ☐ Yes ☐ No
- Does the plan address specific pumping and clean out schedules for all liquid storage structures? ☐ Yes ☐ No
- Does the plan require records to be maintained that document the date, location, weather, and application rate of manure and wastewater that is land applied? ☐ Yes ☐ No ✗
- Is there sufficient land owned or under the control of the operator to properly utilize all manure and wastewater generated by the operation? ☐ Yes ☐ No

  If no:
  - → Does the plan identify the quantity of excess manure being generated? _____ tons/year or gallons/year
  - → Does the plan identify how the excess manure is to be utilized? __________
  - → Is excess manure/wastewater to be transferred off-site? ☐ Yes ☐ No

  If yes:
  - → Does the plan include the necessary arrangements for this transfer? ☐ Yes ☐ No
  - → Does the plan identify the recipients? ☐ Yes ☐ No
- Does the plan address the maintenance of land application equipment? ☐ Yes ☐ No
- Does the plan identify the manure application method to be used? ☐ Yes ☐ No
- Does the plan require periodic calibration of manure application equipment. ☐ Yes ☐ No
- Are the application rates identified in the plan appropriate? ☐ Yes ☐ No

Notes: __________

____

____

On-Site Inspection

- Does the plan reflect the current operational characteristics (number of animals, cropping, etc.)? ☐ Yes ☐ No ✗
- Are the number of acres owned/acres leased consistent with those identified in the plan? ☐ Yes ☐ No ✗
- Is the crop rotation consistent with that identified in the plan used to determine application rates and timing? ☐ Yes ☐ No
- Is the application equipment being used consistent with the equipment identified in the plan? ☐ Yes ☐ No
- Is the land application equipment being used appropriate? ☐ Yes ☐ No
- Is the amount of manure/wastewater being transferred off-site consistent with the amount identified in the plan? ☐ Yes ☐ No
- Are records (name and address of recipient and amount) of off-site manure disposal being maintained (if required)? ☐ Yes ☐ No
- Is manure and wastewater being applied within a 100' setback or within a 35' vegetated buffer to any down gradient surface waters, open tile line intake structures, agricultural well heads or other conduits to surface waters? ☐ Yes ☐ No ✗

* or other documented recommendation from local extension or other source)

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

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Minimum Practice **Record Keeping**

Plan Review

- Identify the required records that the plan identifies are to be maintained at the facility
  - ☐ Manure and wastewater sample nutrient analysis results
  - ☐ Soil sample analysis results that the plan was based upon for all land application areas (Dates of sample: ___/___/___, ___/___/___, ___/___/___, ___/___/___, ___/___/___)
  - ☐ Manure/wastewater storage - date of emptying, level before emptying, and level after emptying, or quantity removed (dry manure)
  - ☐ Storage facility level (weekly)
  - ☐ Inspection log (stormwater diversions, runoff control structures, water lines, surface impoundments, and manure application equipment)
  - ☐ Maintenance log of all equipment necessary to control discharge and meet permit requirements (e.g., maintenance of land application equipment)
  - ☐ Crop planting/harvest dates by field or CMU
  - ☐ Crop type and yield by field or CMU - bushels/acre (seasonally)
  - ☐ Total amount of N and P applied - date, time, and rate (lbs/acre, gallons/acre), weather condition, application method, and equipment used by field or CMU (daily)
  - ☐ On-site precipitation
  - ☐ Animal Inventory
  - ☐ Lease/Rental/Access Agreements for all land not owned by the operator
  - ☐ Name and address of recipients and quantity of manure transferred off-site
- Does the plan require any additional records be maintained at the facility? ☐ Yes ☐ No

  If yes, what are these records? ____________________

  ____
- Does the plan include an emergency action plan to address spills and catastrophic events? ☐ Yes ☐ No

On-Site Inspection

- Are all of the records identified in the plan being maintained and kept current? ☐ Yes ☐ No ✗

  If no, explain: ____________________

  ____
- Are records being maintained at the required frequency? ☐ Yes ☐ No

  If no, explain: ____________________

  ____
- Are records being maintained on-site for the period required by the permit? ☐ Yes ☐ No

  If no, explain: ____________________

  ____
- Do the records include the date, time and estimated volume of any overflows? ☐ Yes ☐ No

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

Plan Adequacy/Discharge Potential

- Is the plan adequately addressing the storage, handling, and application of manure and wastewater to prevent the discharge of pollutants to waters of the US? ☐ Yes ☐ No ✗
- Is there evidence of a past discharge? ☐ Yes ☐ No

  If yes what evidence was identified? ____________________

- Is there any evidence of discharges to waters of the US from other activities at the operation? ☐ Yes ☐ No

  If yes, what evidence was identified? ____________________

- Is there a risk of a future violation of permit conditions? ☐ Yes ☐ No

  If yes, what is the basis for this determination? ____________________

- Does the plan require revision? ☐ Yes ☐ No

  If yes, what specific components of the plan require revision? ____________________

Additional Comments: ____________________

✗ = Questions where a "no" answer may indicate that the NMP is deficient or that the facility may otherwise be in violation of permit requirements.

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CHAPTER 8: ADDITIONAL RESOURCES

A. USDA Funding Programs for CAFOs

The 2002 Farm Bill offers several voluntary conservation programs that can be used by livestock and poultry producers to help them comply with the revised CAFO rules. Under the 1996 Act, a producer who owned or operated a large confined livestock operation was not eligible for cost-share payments to construct an animal waste management facility. The 2002 Act removed that prohibition. In addition, the 2002 Act states that 60 percent of the funds made available for cost-share and incentive payments are to be targeted at practices related to livestock production rather than the 50 percent that was specified in the1996 Act. NRCS provides technical assistance to CAFO operators through conservation planning, design, and implementation. Producers also may obtain assistance from technical service providers. Financial assistance to implement practices and systems is available through the following:

Environmental Quality Incentives Program (EQIP) provides up to 75 percent (up to 90 percent for beginning or limited resource farmers or ranchers) in cost-share funds to construct certain conservation practices, such as grassed waterways, filter strips, manure management facilities, capping abandoned wells, and other practices important to improving and maintaining the health of natural resources in the area. EQIP funds can be used to develop CNMPs, which generally will satisfy the CAFO rules nutrient management plan requirement. At least 60 percent of EQIP financial assistance funds are required by statute to be used on a nationwide basis for livestock and poultry operations, both confined and grazing. All livestock producers can receive EQIP cost-share for waste storage facilities regardless of the size of the operation but only if they implement a CNMP. Each EQIP contract has a payment limitation of $450,000 per individual or entity for the period from fiscal year 2002 - fiscal year 2007.

USDA's National Funding Allocation Process is used to distribute program funds to the States and Territories. The national funding priorities for EQIP under the 2002 Farm Bill are as follows:

- Reductions of nonpoint source pollution, such as nutrients, sediment, pesticides, or excess salinity in impaired watersheds consistent with TMDLs where available, as well as the reduction of ground water contamination and the conservation of ground and water resources;

- Reduction of emissions, such as particulate matter, nitrogen oxides, volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards;

- Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land; and

- Promotion of at-risk species habitat conservation.

Local work groups are used by NRCS at the state level to implement these national priorities. These local work groups–convened by local conservation districts–conduct a conservation needs assessment and, based on these assessments, develop proposals for priority areas. These proposals are submitted to the NRCS State Conservationist, who selects those areas within the state based on the recommendations from the State Technical Committee.

The local work groups are made up of representatives from conservation district board members and key staff; NRCS; Farm Service Agency (FSA); FSA county committees and key staffs; the Cooperative State Research, Education, and Extension Service; and other federal, state, and local agencies interested in natural resource conservation. Their recommendations go to the NRCS-designated conservationist for the local area and then to the State Conservationist, who sets priorities with the advice of the State Technical Committee. The recommendations are integrated into regional and national strategic plans. These strategic plans provide a basis for funding decisions.

Agricultural Management Assistance Program (AMA) provides cost-share funds to assist producers in implementing conservation systems and addressing regulatory requirements. Program funds may be used by CAFO operators to develop and implement a CNMP. AMA funding is limited to producers in the following 15 states: Connecticut, Delaware, Maine, Maryland, Massachusetts, Nevada, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Utah, Vermont, West Virginia, and Wyoming.

Conservation Reserve Program (CRP) provides participants with rental payments and cost-share assistance to take agricultural land out of production. Environmentally desirable land devoted to certain conservation practices including riparian buffers, wetland buffers, and filter strips may be enrolled in CRP at any time under continuous sign-up. Offers are automatically accepted provided the land and producer meet certain eligibility requirements. Offers for continuous sign-up are not subject to competitive bidding. Continuous sign-up contracts are 10 to 15 years in duration.

Other Farm Bill Programs: Other conservation programs may support CAFO operators in their efforts to implement a well-rounded conservation plan. These programs include

- Conservation Reserve Enhancement Program (CREP);
- Wetlands Reserve Program (WRP); and
- Wildlife Habitat Improvement Program (WHIP).

In addition to financial assistance programs under the 2002 Farm Bill, there may be state and local cost share programs available to support CAFO operators. Permit writers should determine whether such programs exist within the state or region for which they are responsible.

The information presented in this section was obtained from the following USDA Web site, which summarizes funding opportunities for animal feeding operations: http://www.nrcs.usda.gov/programs/afo/2003pdf/CAFO%20Rule%20Fact%20Sheet.pdf.

B. USDA and EPA Livestock and Poultry Environmental Stewardship Curriculum

The Livestock and Poultry Environmental Stewardship (LPES) curriculum is a nationally developed and regionally piloted training program. The curriculum was developed by a national team of more than30 experts from 15 land-grant universities, USDA's NRCS, and USDA's Agricultural Research Service (ARS) who prepared, peer reviewed, and pilot tested the LPES curriculum with assistance from Mid-West Plan Service (MWPS) and guidance from EPA's National Agriculture Compliance Center (Ag Center). The LPES curriculum development effort was funded by a grant from the EPA's Ag Center with program oversight through the USDA. The goal of the LPES program is to provide producers, industry stakeholders, and educators with access to the latest science-based information. Instructional materials are available for each of the 26 lessons that make up the curriculum. This material can be ordered from the MWPS, which is an organization of extension and research agricultural engineers from 12 universities plus representatives of the USDA (http://www.mwpshq.org).

C. EPA Programs and Information

Unified National Strategy for Animal Feeding Operations

U.S. Department of Agriculture/U.S. Environmental Protection Agency Unified National Strategy for Animal Feeding Operations, March 9, 1999.
http://www.epa.gov/npdes/pubs/finafost.pdf

CAFO Final Rule Web Page

This Web site provides access to the text of the rule and preamble, outreach brochures, supporting documents, and guidance documents.
http://www.epa.gov/npdes/caforule

Clean Water Act Section 319 Nonpoint Source Management Program

EPA Office of Wetlands, Oceans and Watersheds, Clean Water Act Section 319
http://www.epa.gov/owow/nps/cwact.html

EMS Resources

This Web site provides information and resources related to Environmental Management Systems (EMSs) for businesses, associations, the public, and state and federal agencies.
http://www.epa.gov/ems

EPA's Position Statement on Environmental Management Systems (May 15, 2002)

http://www.epa.gov/ems/policy/EMS_PositionStatementFinal.pdf

NPDES Permit Writers' Manual

U.S. EPA NPDES Permit Writers' Manual, EPA 833-B-96-003, December 1, 1996.
To download individual chapters or the entire document, go to EPA's NPDES Permit Writers' Manual page at http://cfpub.epa.gov/npdes/writermanual.cfm?program_id=45.

NPDES Permit Program Basics

This Web site provides basic permitting tools and information.
http://cfpub.epa.gov/npdes/home.cfm?program_id=45.

National Agriculture Compliance Assistance Center (Ag Center)

http://www.epa.gov/agriculture/

National Management Measures to Control Nonpoint Source Pollution from Agriculture

EPA 841-B-03-004, 2003
Includes information on the selection and implementation of BMPs to control the contribution of pollutants to surface water.
http://www.epa.gov/owow/nps/agmm/index.html

Permit Compliance System

http://www.epa.gov/compliance/planning/data/water/pcssys.html

Source Water Protection Programs

EPA Office of Groundwater and Drinking Water, Source Water Protection
http://www.epa.gov/safewater/protect.html

TMDL Programs

EPA Office of Wetlands, Oceans and Watersheds, TMDL Program
http://www.epa.gov/OWOW/tmdl/index.html

USDA and EPA Livestock and Poultry Environmental Stewardship Curriculum

http://www.lpes.org/

United Egg Producers voluntary EMS program

EPA Project XL, United Egg Producers.
http://www.epa.gov/projectxl/uep/

D. USDA Programs and Information

2002 Farm Bill

USDA's online gateway to information about the 2002 Farm Bill.
http://www.usda.gov/farmbill/index.html

Cooperative Extension Service Agents and Specialists

Directory of State Extension Service Directors and Administrators.
http://www.reeusda.gov/hrd/statedir.htm

Land Grant Universities

This CSREES web site provides directory of land grant universities. Click on a state to link to a list of land-grant university web sites.
http://www.reeusda.gov/1700/statepartners/usa.htm

NRCS Nutrient Management Technical Practice Standard 590

USDA NRCS Nutrient Management Technical Resources, Code 590.
http://www.nrcs.usda.gov/technical/ECS/nutrient/590.html

NRCS Nutrient Management Technical Resources

This Web site provides computer-based tools to facilitate the development and implementation of NMPs.
http://www.nrcs.usda.gov/technical/nutrient.html

State NRCS Field Office Technical Guidance

Click on the map to find available technical guidance for states and counties.
http://www.nrcs.usda.gov/technical/efotg/

State Technical Standards for Nutrient Management

Use these links to NRCS State offices to search for state nutrient management standards.
http://www.nrcs.usda.gov/about/organization/regions.html#stat

Financial & Technical Assistance Available to Concentrated Animal Feeding Operation Owners and Operators

Downloadable pdf document from USDA/NRCS (2003).
http://www.nrcs.usda.gov/programs/afo/2003pdf/CAFO%20Rule%20Fact%20Sheet.pdf

USDA Agricultural Research Service

http://www.ars.usda.gov

USDA Cooperative State Research, Education, and Extension Service

http://www.reeusda.gov/

USDA Farm Service Agency

http://www.fsa.usda.gov/

USDA Farm Service Agency, Conservation Reserve Program

http://www.fsa.usda.gov/dafp/cepd/crp.htm

USDA Farm Service Agency, Conservation Reserve Enhancement Program

http://www.fsa.usda.gov/dafp/cepd/crep.htm

USDA Natural Resources Conservation Service (NRCS)

http://www.nrcs.usda.gov

USDA NRCS Conservation Programs

Environmental Quality Incentives Program, Agricultural Management Assistance Program, Wetlands Reserve Program, Wildlife Habitat Incentives Program.
http://www.nrcs.usda.gov/programs/

USDA NRCS's CNMP Technical Guidance

Draft Comprehensive Nutrient Management Planning Technical Guidance, National Planning Procedures Handbook, Subpart E, Parts 600.50-600.54 and Subpart F, Part 600.75.
http://www.nrcs.usda.gov/programs/afo/cnmp_guide_index.html

USDA National Nutrient Management Policy

NRCS Online Directives Management System, General Manual, Title 190, Part 402 - Nutrient Management, May 1999.
http://www.nrcs.usda.gov/technical/ecs/nutrient/gm-190.html

E. Associations and Trade Groups

American Society of Agronomy (ASA)

http://www.agronomy.org/

Certified Crop Advisors (CCA)

http://www.agronomy.org/cca/

Certified Professional Agronomists (CPAg)

http://www.agronomy.org/certification/agronomy.html

Certified Professional Crop Scientists (CPCSc)

http://www.agronomy.org/certification/crops.html

Certified Professional Soil Scientists (CPSSc)

http://www.agronomy.org/certification/soils.html

ISO 14001

This Web site provides information on ISO 14001 and other standards from the International Standards Organization.
http://www.iso.org/iso/en/ISOOnline.frontpage

National Alliance of Independent Crop Consultants (NAICC)

http://www.naicc.org/

National Association of Conservation Districts (NACD)

http://www.nacdnet.org

National Association of State Departments of Agriculture (NASDA)

http://www.nasda.org

National Cattleman's Beef Association (NCBA)

http://www.beef.org

National Center for Manure and Animal Waste Management

http://www.cals.ncsu.edu/waste_mgt/natlcenter/center.htm

National Milk Producers Federation (NMPF)

http://www.nmpf.org

National Pork Producers Council (NPPC)

http://www.nppc.org

National Turkey Federation (NTF)

http://www.turkeyfed.org

SERA-17

http://www.soil.ncsu.edu/sera17

United States Poultry and Egg Association

http://www.poultryegg.org

APPENDIX A: EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS FOR CONCENTRATED ANIMAL FEEDING OPERATIONS

PART 412—CONCENTRATED ANIMAL FEEDING OPERATIONS (CAFO) POINT SOURCE CATEGORY

Authority: 33 U.S.C. 1311, 1314, 1316, 1317, 1318, 1342, 1361.

§ 412.1 General applicability.

This part applies to manure, litter, and/or process wastewater discharges resulting from concentrated animal feeding operations (CAFOs). Manufacturing and/or agricultural activities which may be subject to this part are generally reported under one or more of the following Standard Industrial Classification (SIC) codes: SIC 0211, SIC 0213, SIC 0214, SIC 0241, SIC 0251, SIC 0252, SIC 0253, SIC 0254, SIC 0259, or SIC 0272 (1987 SIC Manual).

§ 412.2 General definitions.

As used in this part:

(a) The general definitions and abbreviations at 40 CFR part 401 apply.

(b) *Animal Feeding Operation (AFO)* and *Concentrated Animal Feeding Operation (CAFO)* are defined at 40 CFR 122.23.

(c) *Fecal coliform* means the bacterial count (Parameter 1) at 40 CFR 136.3 in Table 1A, which also cites the approved methods of analysis.

(d) *Process wastewater* means water directly or indirectly used in the operation of the CAFO for any or all of the following: spillage or overflow from animal or poultry watering systems; washing, cleaning, or flushing pens, barns, manure pits, or other CAFO facilities; direct contact swimming, washing, or spray cooling of animals; or dust control. Process wastewater also includes any water which comes into contact with any raw materials, products, or byproducts including manure, litter, feed, milk, eggs, or bedding.

(e) *Land application* area means land under the control of an AFO owner or operator, whether it is owned, rented, or leased, to which manure, litter, or process wastewater from the production area is or may be applied.

(f) *New source* is defined at 40 CFR 122.2. New source criteria are defined at 40 CFR 122.29(b).

(g) *Overflow* means the discharge of manure or process wastewater resulting from the filling of wastewater or manure storage structures beyond the point at which no more manure, process wastewater, or storm water can be contained by the structure.

(h) *Production area* means that part of an AFO that includes the animal confinement area, the manure storage area, the raw materials storage area, and the waste containment areas. The animal confinement area includes but is not limited to open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milkrooms, milking centers, cowyards, barnyards, medication pens, walkers, animal walkways, and stables. The manure storage area includes but is not limited to lagoons, runoff ponds, storage sheds, stockpiles, under house or pit storages, liquid impoundments, static piles, and composting piles. The raw materials storage area includes but is not limited to feed silos, silage bunkers, and bedding materials. The waste containment area includes but is not limited to settling basins, and areas within berms and diversions which separate uncontaminated storm water. Also included in the definition of production area is any egg washing or egg processing facility, and any area used in the storage, handling, treatment, or disposal of mortalities.

(i) *Ten(10)-year, 24-hour rainfall event, 25-year, 24-hour rainfall event, and 100-year, 24-hour rainfall event* mean precipitation events with a probable recurrence interval of once in ten years, or twenty five years, or one hundred years, respectively, as defined by the National Weather Service in Technical Paper No. 40, ''Rainfall Frequency Atlas of the United States,'' May, 1961, or equivalent regional or State rainfall probability information developed from this source.

(j) Analytical methods. The parameters that are regulated or referenced in this part and listed with approved methods of analysis in Table1B at 40 CFR 136.3 are defined as follows:

(1) *Ammonia* (as N) means ammonia reported as nitrogen.

(2) BOD_5 means 5-day biochemical oxygen demand.

(3) *Nitrate* (as N) means nitrate reported as nitrogen.

(4) *Total dissolved solids* means nonfilterable residue.

(k) The parameters that are regulated or referenced in this part and listed with approved methods of analysis in Table 1A at 40 CFR 136.3 are defined as follows:

(1) *Fecal coliform* means fecal coliform bacteria.

(2) *Total coliform* means all coliform bacteria.

§ 412.3 General pretreatment standards.

Any source subject to this part that introduces process wastewater pollutants into a publicly owned treatment works (POTW) must comply with 40 CFR part 403.

§ 412.4 Best management practices (BMPs) for land application of manure, litter, and process wastewater.

(a) Applicability. This section applies to any CAFO subject to subpart C of this part (Dairy and Beef Cattle other than Veal Calves) or subpart D of this part (Swine, Poultry, and Veal Calves).

(b) Specialized definitions.

(1) *Setback* means a specified distance from surface waters or potential conduits to surface waters where manure, litter, and process wastewater may not be land applied. Examples of conduits to surface waters include but are not limited to: open tile line intake structures, sinkholes, and agricultural well heads.

(2) *Vegetated buffer* means a narrow, permanent strip of dense perennial vegetation established parallel to the contours of and perpendicular to the dominant slope of the field for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching surface waters.

(3) *Multi-year phosphorus* application means phosphorus applied to a field in excess of the crop needs for that year. In multi-year phosphorus applications, no additional manure, litter, or process wastewater is applied to the same land in subsequent years until the applied phosphorus has been removed from the field via harvest and crop removal.

(c) Requirement to develop and implement best management practices. Each CAFO subject to this section that land applies manure, litter, or process wastewater, must do so in accordance with the following practices:

(1) Nutrient management plan. The CAFO must develop and implement a nutrient management plan that incorporates the requirements of paragraphs (c)(2) through (c)(5) of this section based on a field-specific assessment of the potential for nitrogen and phosphorus transport from the field and that addresses the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters.

(2) Determination of application rates. Application rates for manure, litter, and other process wastewater applied to land under the ownership or operational control of the CAFO must minimize phosphorus and nitrogen transport from the field to surface waters in compliance with the technical standards for nutrient management established by the Director. Such technical standards for nutrient management shall:

(i) Include a field-specific assessment of the potential for nitrogen and phosphorus transport from the field to surface waters, and address the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and phosphorus movement to surface waters; and

(ii) Include appropriate flexibilities for any CAFO to implement nutrient management practices to comply with the technical standards, including consideration of multi-year phosphorus application on fields that do not have a high potential for phosphorus runoff to surface water, phased implementation of phosphorus-based nutrient management, and other components, as determined appropriate by the Director.

(3) Manure and soil sampling. Manure must be analyzed a minimum of once annually for nitrogen and phosphorus content, and soil analyzed a minimum of once every five years for phosphorus content. The results of these analyses are to be used in determining application rates for manure, litter, and other process wastewater.

(4) Inspect land application equipment for leaks. The operator must periodically inspect equipment used for land application of manure, litter, or process wastewater.

(5) Setback requirements. Unless the CAFO exercises one of the compliance alternatives provided for in (c)(5)(i) or (c)(5)(ii) of this section, manure, litter, and process wastewater may not be applied closer than 100 feet to any down-gradient surface waters, open tile line intake structures, sinkholes, agricultural well heads, or other conduits to surface waters.

(i) Vegetated buffer compliance alternative. As a compliance alternative, the CAFO may substitute the 100-foot setback with a 35-foot wide vegetated buffer where applications of manure, litter, or process wastewater are prohibited.

(ii) Alternative practices compliance alternative. As a compliance alternative, the CAFO may demonstrate that a setback or buffer is not necessary because implementation of alternative conservation practices or field-specific conditions will provide pollutant reductions equivalent or better than the reductions that would be achieved by the 100-foot setback.

Subpart A—Horses and Sheep

§ 412.10 Applicability.

This subpart applies to discharges resulting from the production areas at horse and sheep CAFOs. This subpart does not apply to such CAFOs with less than the following capacities: 10,000 sheep or 500 horses.

§ 412.12 Effluent limitations attainable by the application of the best practicable control technology currently available (BPT).

(a) Except as provided in 40 CFR 125.30 through 125.32, and subject to the provisions of paragraph (b) of this section, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BPT: There shall be no discharge of process waste water pollutants to navigable waters.

(b) Process waste pollutants in the overflow may be discharged to navigable waters whenever rainfall events, either chronic or catastrophic, cause an overflow of process waste water from a facility designed, constructed and operated to contain all process generated waste waters plus the runoff from a 10-year, 24-hour rainfall event for the location of the point source.

§ 412.13 Effluent limitations attainable by the application of the best available technology economically achievable (BAT).

(a) Except as provided in 40 CFR 125.30 through 125.32 and when the provisions of paragraph (b) of this section apply, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BAT: There shall be no discharge of process waste water pollutants into U.S. waters.

(b) Whenever rainfall events cause an overflow of process wastewater from a facility designed, constructed, operated, and maintained to contain all process-generated wastewaters plus the runoff from a 25-year, 24-hour rainfall event at the location of the point source, any process wastewater pollutants in the overflow may be discharged into U.S. waters.

§ 412.15 Standards of performance for new sources (NSPS)

(a) Except as provided in paragraph (b) of this section, any new source subject to this subpart must achieve the following performance standards: There must be no discharge of process wastewater pollutants into U.S. waters.

(b) Whenever rainfall events cause an overflow of process wastewater from a facility designed, constructed, operated, and maintained to contain all process-generated wastewaters plus the runoff from a 25-year, 24-hour rainfall event at the location of the point source, any process wastewater pollutants in the overflow may be discharged into U.S. waters.

Subpart B—Ducks

§ 412.20 Applicability.

This subpart applies to discharges resulting from the production areas at dry lot and wet lot duck CAFOs. This subpart does not apply to such CAFOs with less than the following capacities: 5,000 ducks.

§ 412.21 Special definitions.

For the purposes of this subpart:

(a) *Dry lot* means a facility for growing ducks in confinement with a dry litter floor cover and no access to swimming areas.

(b) *Wet lot* means a confinement facility for raising ducks which is open to the environment, has a small number of sheltered areas, and with open water runs and swimming areas to which ducks have free access.

§ 412.22 Effluent limitations attainable by the application of the best practicable control technology currently available (BPT).

(a) Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart shall achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the (BPT):

Regulated parameter	Maximum daily[1]	Maximum monthly average[1]	Maximum daily[2]	Maximum monthly average[2]
BOD_5	3.66	2.0	1.66	0.91
Fecal coliform	([3])	([3])	([3])	([3])

1 Pounds per 1000 ducks
2 Kilograms per 1000 ducks
3 Not to exceed MPN of 400 per 100 ml at any time.

§ 412.25 New source performance standards (NSPS).

(a) Except as provided in paragraph (b) of this section, any new source subject to this subpart must achieve the following performance standards: There must be no discharge of process waste water pollutants into U.S. waters.

(b) Whenever rainfall events cause an overflow of process wastewater from a facility designed, constructed, operated, and maintained to contain all process-generated wastewaters plus the runoff from a 25-year, 24-hour rainfall event at the location of the point source, any process wastewater pollutants in the overflow may be discharged into U.S. waters.

§ 412.26 Pretreatment standards for new sources (PSNS).

(a) Except as provided in 40 CFR 403.7 and in paragraph (b) of this section, any new source subject to this subpart must achieve the following performance standards: There must be no discharge of process waste water pollutants into a POTW.

(b) Whenever rainfall events cause an overflow of process wastewater from a facility designed, constructed, operated, and maintained to contain all process-generated wastewaters plus the runoff from a 25-year, 24-hour rainfall event at the location of the point source, any process wastewater pollutants in the overflow may be discharged into U.S. waters.

Subpart C—Dairy Cows and Cattle Other Than Veal Calves

§ 412.30 Applicability.

This subpart applies to operations defined as concentrated animal feeding operations (CAFOs) under 40 CFR 122.23 and includes the following animals: mature dairy cows, either milking or dry; cattle other than mature dairy cows or veal calves. Cattle other than mature dairy cows includes but is not limited to heifers, steers, and bulls. This subpart does not apply to such CAFOs with less than the following capacities: 700 mature dairy cows whether milked or dry; 1,000 cattle other than mature dairy cows or veal calves.

§ 412.31 Effluent limitations attainable by the application of the best practicable control technology currently available (BPT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BPT:

(a) For CAFO production areas. Except as provided in paragraphs (a)(1) through (a)(2) of this paragraph, there must be no discharge of manure, litter, or process wastewater pollutants into waters of the U.S. from the production area.

(1) Whenever precipitation causes an overflow of manure, litter, or process wastewater, pollutants in the overflow may be discharged into U.S. waters provided:

(i) The production area is designed, constructed, operated and maintained to contain all manure, litter, and process wastewater including the runoff and the direct precipitation from a 25-year, 24-hour rainfall event;

(ii) The production area is operated in accordance with the additional measures and records required by § 412.37(a) and (b).

(2) Voluntary alternative performance standards. Any CAFO subject to this subpart may request the Director to establish NPDES permit effluent limitations based upon site specific alternative technologies that achieve a quantity of pollutants discharged from the production area equal to or less than the quantity of pollutants that would be discharged under the baseline performance standards as provided by paragraph (a)(1) of this section.

(i) Supporting information. In requesting site-specific effluent limitations to be included in the NPDES permit, the CAFO owner or operator must submit a supporting technical analysis and any other relevant information and data that would support such site-specific effluent limitations within the time frame provided by the Director. The supporting technical analysis must include calculation of the quantity of pollutants discharged, on a mass basis where appropriate, based on a site-specific analysis of a system designed, constructed, operated, and maintained to contain all manure, litter, and process wastewater, including the runoff from a 25-year, 24-hour rainfall event. The technical analysis of the discharge of pollutants must include:

(A) All daily inputs to the storage system, including manure, litter, all process waste waters, direct precipitation, and runoff.

(B) All daily outputs from the storage system, including losses due to evaporation, sludge removal, and the removal of waste water for use on cropland at the CAFO or transport off site.

(C) A calculation determining the predicted median annual overflow volume based on a 25-year period of actual rainfall data applicable to the site.

(D) Site-specific pollutant data, including N, P, BOD_5, TSS, for the CAFO from representative sampling and analysis of all sources of input to the storage system, or other appropriate pollutant data.

(E) Predicted annual average discharge of pollutants, expressed where appropriate as a mass discharge on a daily basis (lbs/day), and calculated considering paragraphs (a)(3)(i)(A) through (a)(3)(i)(D).

(ii) The Director has the discretion to request additional information to supplement the supporting technical analysis, including inspection of the CAFO.

(3) The CAFO shall attain the limitations and requirements of this paragraph as of the date of permit coverage.

(b) For CAFO land application areas. Discharges from land application areas are subject to the following requirements:

(1) Develop and implement the best management practices specified in § 412.4;
(2) Maintain the records specified at § 412.37 (c);
(3) The CAFO shall attain the limitations and requirements of this paragraph by December 31, 2006.

§ 412.32 Effluent limitations attainable by the application of the best conventional pollutant control technology (BCT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BCT:

(a) For CAFO production areas: the CAFO shall attain the same limitations and requirements as § 412.31(a).

(b) For CAFO land application areas: the CAFO shall attain the same limitations and requirements as § 412.31(b).

§ 412.33 Effluent limitations attainable by the application of the best available technology economically achievable (BAT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BAT:

(a) For CAFO production areas: the CAFO shall attain the same limitations and requirements as § 412.31(a).

(b) For CAFO land application areas: the CAFO shall attain the same limitations and requirements as § 412.31(b).

§ 412.35 New source performance standards (NSPS).

Any new point source subject to this subpart must achieve the following effluent limitations representing the application of NSPS:

(a) <u>For CAFO production areas</u>. The CAFO shall attain the same limitations and requirements as § 412.31(a)(1) and § 412.31(a)(2).

(b) <u>For CAFO land application areas</u>: The CAFO shall attain the same limitations and requirements as § 412.31(b)(1) and § 412.31(b)(2).

(c) The CAFO shall attain the limitations and requirements of this paragraph as of the date of permit coverage.

(d) Any source subject to this subpart that commenced discharging after [insert date 10 years prior to the date that is 60 days from the publication date of the final rule] and prior to [insert date that is 60 days from the publication date of the final rule] which was a new source subject to the standards specified in § 412.15, revised as of July 1, 2002, must continue to achieve those standards for the applicable time period specified in 40 CFR 122.29(d)(1). Thereafter, the source must achieve the standards specified in § 412.31(a) and (b).

§ 412.37 Additional measures.

(a) Each CAFO subject to this subpart must implement the following requirements:

(1) <u>Visual inspections</u>. There must be routine visual inspections of the CAFO production area. At a minimum, the following must be visually inspected:

(i) Weekly inspections of all storm water diversion devices, runoff diversion structures, and devices channeling contaminated storm water to the wastewater and manure storage and containment structure;

(ii) Daily inspection of water lines, including drinking water or cooling water lines;

(iii) Weekly inspections of the manure, litter, and process wastewater impoundments; the inspection will note the level in liquid impoundments as indicated by the depth marker in paragraph (a)(2) of this section.

(2) <u>Depth marker</u>. All open surface liquid impoundments must have a depth marker which clearly indicates the minimum capacity necessary to contain the runoff and direct precipitation of the 25-year, 24-hour rainfall event, or, in the case of new sources subject to the requirements in § 412.46 of this part, the runoff and direct precipitation from a 100-year, 24-hour rainfall event.

(3) Corrective actions. Any deficiencies found as a result of these inspections must be corrected as soon as possible.

(4) Mortality handling. Mortalities must not be disposed of in any liquid manure or process wastewater system, and must be handled in such a way as to prevent the discharge of pollutants to surface water, unless alternative technologies pursuant to § 412.31(a)(2) and approved by the Director are designed to handle mortalities.

(b) Record keeping requirements for the production area. Each CAFO must maintain on-site for a period of five years from the date they are created a complete copy of the information required by 40 CFR 122.21(i)(1) and 40 CFR 122.42(e)(1)(ix) and the records specified in paragraphs (b)(1) through (b)(6) of this section. The CAFO must make these records available to the Director and, in an authorized State, the Regional Administrator, or his or her designee, for review upon request.

(1) Records documenting the inspections required under paragraph (a)(1) of this section;

(2) Weekly records of the depth of the manure and process wastewater in the liquid impoundment as indicated by the depth marker under paragraph (a)(2) of this section;

(3) Records documenting any actions taken to correct deficiencies required under paragraph (a)(3) of this section. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors preventing immediate correction;

(4) Records of mortalities management and practices used by the CAFO to meet the requirements of paragraph (a)(4) of this section.

(5) Records documenting the current design of any manure or litter storage structures, including volume for solids accumulation, design treatment volume, total design volume, and approximate number of days of storage capacity;

(6) Records of the date, time, and estimated volume of any overflow.

(c) Record keeping requirements for the land application areas. Each CAFO must maintain on-site a copy of its site-specific nutrient management plan. Each CAFO must maintain on-site for a period of five years from the date they are created a complete copy of the information required by § 412.4 and 40 CFR 122.42(e)(1)(ix) and the records specified in paragraphs (c)(1) through (c)(10) of this section. The CAFO must make these records available to the Director and, in an authorized State, the Regional Administrator, or his or her designee, for review upon request.

(1) Expected crop yields;

(2) The date(s) manure, litter, or process waste water is applied to each field;

(3) Weather conditions at time of application and for 24 hours prior to and following application;

(4) Test methods used to sample and analyze manure, litter, process waste water, and soil;

(5) Results from manure, litter, process waste water, and soil sampling;

(6) Explanation of the basis for determining manure application rates, as provided in the technical standards established by the Director.

(7) Calculations showing the total nitrogen and phosphorus to be applied to each field, including sources other than manure, litter, or process wastewater;

(8) Total amount of nitrogen and phosphorus actually applied to each field, including documentation of calculations for the total amount applied;

(9) The method used to apply the manure, litter, or process wastewater;

(10) Date(s) of manure application equipment inspection.

Subpart D—Swine, Poultry, and Veal Calves

§ 412.40 Applicability.

This subpart applies to operations defined as concentrated animal feeding operations (CAFOs) under 40 CFR 122.23 and includes the following animals: swine; chickens; turkeys; and veal calves. This subpart does not apply to such CAFOs with less than the following capacities: 2,500 swine each weighing 55 lbs. or more; 10,000 swine each weighing less than 55 lbs.; 30,000 laying hens or broilers if the facility uses a liquid manure handling system; 82,000 laying hens if the facility uses other than a liquid manure handling system; 125,000 chickens other than laying hens if the facility uses other than a liquid manure handling system; 55,000 turkeys; and 1,000 veal calves.

§ 412.43 Effluent limitations attainable by the application of the best practicable control technology currently available (BPT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BPT:

(a) For CAFO production areas.

(1) The CAFO shall attain the same limitations and requirements as § 412.31(a)(1) through (a)(2).

(2) The CAFO shall attain the limitations and requirements of this paragraph as of the date of permit coverage.

(b) For CAFO land application areas.

(1) The CAFO shall attain the same limitations and requirements as § 412.31(b)(1) and (b)(2).

(2) The CAFO shall attain the limitations and requirements of this paragraph by December 31, 2006.

§ 412.44 Effluent limitations attainable by the application of the best conventional pollutant control technology (BCT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BCT:

(a) For CAFO production areas: the CAFO shall attain the same limitations and requirements as § 412.43(a).

(b) For CAFO land application areas: the CAFO shall attain the same limitations and requirements as § 412.43(b).

§ 412.45 Effluent limitations attainable by the application of the best available technology economically achievable (BAT).

Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the application of BAT:

(a) For CAFO production areas: the CAFO shall attain the same limitations and requirements as § 412.43(a).

(b) For CAFO land application areas: the CAFO shall attain the same limitations and requirements as § 412.43(b).

§ 412.46 New source performance standards (NSPS).

Any new source subject to this subpart must achieve the following effluent limitations representing the application of NSPS:

(a) For CAFO production areas. There must be no discharge of manure, litter, or process wastewater pollutants into waters of the U.S. from the production area, subject to paragraphs (a)(1) through (a)(3) of this section.

(1) Waste management and storage facilities designed, constructed, operated, and maintained to contain all manure, litter, and process wastewater including the runoff and the direct precipitation from a 100-year, 24-hour rainfall event and operated in accordance with the additional measures and records required by § 412.47(a) and (b), will fulfill the requirements of this section.

(2) The production area must be operated in accordance with the additional measures required by § 412.47(a) and (b).

(3) Provisions for upset/bypass, as provided in 40 CFR 122.41(m)-(n), apply to a new source subject to this provision.

(b) For CAFO land application areas: the CAFO shall attain the same limitations and requirements as § 412.43(b)(1).

(c) The CAFO shall attain the limitations and requirements of this paragraph as of the date of permit coverage.

(d) Voluntary superior environmental performance standards. Any new source CAFO subject to this subpart may request the Director to establish alternative NPDES permit limitations based upon a demonstration that site-specific innovative technologies will achieve overall environmental performance across all media which is equal to or superior to the reductions achieved by baseline standards as provided by § 412.46(a). The quantity of pollutants discharged from the production area must be accompanied by an equivalent or greater reduction in the quantity of pollutants released to other media from the production area (e.g., air emissions from housing and storage) and/or land application areas for all manure, litter, and process wastewater at on-site and off-site locations. The comparison of quantity of pollutants must be made on a mass basis where appropriate. The Director has the discretion to request supporting information to supplement such a request.

(e) Any source subject to this subpart that commenced discharging after [insert date 10 years prior to the date that is 60 days from the publication date of the final rule] and prior to [insert date that is 60 days from the publication date of the final rule] which was a new source subject to the standards specified in § 412.15, revised as of July 1, 2002, must continue to achieve those standards for the applicable time period specified in 40 CFR 122.29(d)(1). Thereafter, the source must achieve the standards specified in § 412.43(a) and (b).

§ 412.47 Additional measures.

(a) Each CAFO subject to this subpart must implement the requirements of § 412.37(a).

(b) Each CAFO subject to this subpart must comply with the record-keeping requirements of § 412.37(b).

(c) Each CAFO subject to this subpart must comply with the record-keeping requirements of § 412.37(c).

APPENDIX B - SAMPLE OWNER/OPERATOR INSPECTION CHECKLIST FOR A LARGE CAFO[1]

PRODUCTION AREA

Conduct visual inspections of:

- ❑ Water lines, including drinking water or cooling water lines (daily).
- ❑ All storm water diversion devices (weekly).
- ❑ Runoff diversion devices (weekly).
- ❑ Devices that channel contaminated storm water to the wastewater and manure storage and containment structure (weekly).
- ❑ Manure, litter, and process wastewater impoundments (weekly).
- ❑ The level of the liquid in an open surface liquid impoundment as indicated by a depth marker (weekly).

LAND APPLICATION AREA

Conduct periodic inspections of:

- ❑ The equipment used to land-apply manure, litter, or process wastewater.

[1]This checklist applies to a large CAFO with a capacity equal to or greater than 700 mature dairy cows whether milked or dry; 1,000 cattle (other than mature dairy cows and veal calves); 2,500 swine each weighing 55 pounds or more; 10,000 swine each weighing less than 55 pounds; 30,000 laying hens or broilers if the facility uses a liquid manure handling system; 82,000 laying hens if the facility uses other than a liquid manure handling system; 125,000 chickens other than laying hens if the facility uses other than a liquid manure handling system; 55,000 turkeys; or 1,000 veal calves.

APPENDIX C - SAMPLE RECORDKEEPING CHECKLIST FOR THE PRODUCTION AREA AND LAND APPLICATION AREA AT A LARGE CAFO[1]

GENERAL INFORMATION

Maintain records that contain the following general information for the CAFO:

- ❑ The name of the owner or operator of the CAFO.
- ❑ The location and mailing address of the CAFO
- ❑ The latitude and longitude of the entrance to the production area.
- ❑ The number and types of animals confined and whether the animals are in open confinement or housed under roofs.
- ❑ The type of containment and storage, and the total capacity for manure, litter, and process wastewater storage in either gallons or tons.
- ❑ The number of acres under the control of the owner or operator available for land application of manure, litter, or process wastewater.
- ❑ The estimated amount/volume (tons or gallons) of manure, litter, and process wastewater transferred to other persons annually.
- ❑ Documentation that the applicable effluent limitations guidelines and standards have been met.

PRODUCTION AREA

Maintain records for the production area that document:

[1]This checklist applies to a large CAFO with a capacity equal to or greater than 700 mature dairy cows whether milked or dry; 1,000 cattle (other than mature dairy cows and veal calves); 2,500 swine each weighing 55 pounds or more; 10,000 swine each weighing less than 55 pounds; 30,000 laying hens or broilers if the facility uses a liquid manure handling system; 82,000 laying hens if the facility uses other than a liquid manure handling system; 125,000 chickens other than laying hens if the facility uses other than a liquid manure handling system; 55,000 turkeys; or 1,000 veal calves.

- ❑ The total design volume for manure, litter, or process wastewater storage structures and the estimated number of days of storage capacity for each structure.

- ❑ The date, time, and estimated volume of any overflow from a manure, litter, or process wastewater storage structure.

- ❑ The procedures in place to ensure proper operation and maintenance of manure, litter, and process wastewater storage structures.

- ❑ Proper management of dead animals (i.e., mortalities) to ensure that they are not disposed of in a liquid manure, storm water, or process wastewater storage or treatment system that is not designed specifically to treat dead animals.

- ❑ How clean water is diverted, as appropriate, from the production area.

- ❑ How direct contact of confined animals with surface water bodies is prevented.

- ❑ How chemicals and other contaminants handled on-site are disposed to ensure they are not disposed in any manure, litter, process wastewater, or storm water storage or treatment system that is not designed specifically to treat such chemicals and other contaminants.

- ❑ Results of the daily inspections of water lines, including drinking water or cooling water lines.

- ❑ Results of the weekly inspections of the storm water diversion devices, runoff diversion structures, and devices channeling contaminated storm water to the wastewater and manure storage and containment structure.

- ❑ Results of the weekly inspections of the manure, litter, and process wastewater impoundments.

- ❑ Actions taken to correct deficiencies found during the daily and weekly inspections.

- ❑ Factors that prevented any deficiencies from being corrected within 30 days after they were discovered.

- ❑ The type of depth marker used in open surface liquid impoundments to indicate the minimum capacity needed to contain the runoff and direct precipitation for either a 25-year, 24-hour rainfall event or a 100-year, 24-hour rainfall event, whichever is appropriate.

- ❑ Results the depth measurements of the manure and process wastewater in an open liquid surface impoundment using a depth marker.

LAND APPLICATION AREA

Maintain the records for the land application area that document:

- ❑ The site-specific nutrient management plan.
- ❑ Expected crop yields.
- ❑ Date(s) manure, litter, or process waste water was applied to each field.
- ❑ Weather conditions at the time of land application and for 24 hours prior to land application.
- ❑ Test methods used to sample and analyze manure, litter, process waste water, and soil.
- ❑ Results from manure, litter, process waste water, and soil sampling.
- ❑ Explanation of the basis for determining the manure application rates.
- ❑ Calculations showing the total nitrogen and phosphorus to be applied to each field, including sources other than manure, litter, or process waste water.
- ❑ Total amount of nitrogen and phosphorus actually applied to each field.
- ❑ Method used to apply the manure, litter, or process waste water.
- ❑ Date(s) of manure application equipment inspection.

APPENDIX D - MEASURING THE AMOUNT OF ANIMAL WASTE

Determining the amount of animal waste produced and collected at your farm is essential to successful nutrient management. You can estimate the amount of animal waste that is available for land application based on the quantity of animal waste collected at cleaning time or by calculating your volume in storage. Include animal waste from all sources (e.g., scraped barns, drylots, lagoons, animal waste pits, solid separators, calf huts) in your calculation.

Description

Estimating the total amount of animal waste in storage is a primary element to determine the amount of nutrients you have available, and by extension, the total number of acres that can be fertilized at your calibration rate (see Appendix J). To determine your total amount of animal waste, you will need to estimate the volume of animal waste in each pile or container. This procedure is described below.

Instructions for Calculating Animal Waste in Above-Ground Piles

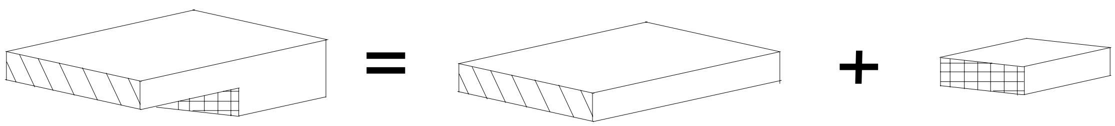
The volume of your animal waste pile can be calculated by transforming the pile's shape into a common geometric shape, such as a cube or a pyramid. To calculate volume, all you will need to know is the formula for the simple shape (see the common volume equations at the end of this appendix) and the dimensions of your pile. For example, if you store your animal waste in a rectangular box, then the formula to use is:

Volume = Length * Width * Height

Next, you will need to measure the box's length, width, and height (also called depth) and plug these numbers into the volume equation. Make sure your measurement units for all dimensions (i.e., sides) are consistent. For example, when measuring sides of your container, make sure you consistently measure in feet, yards, meters, etc.

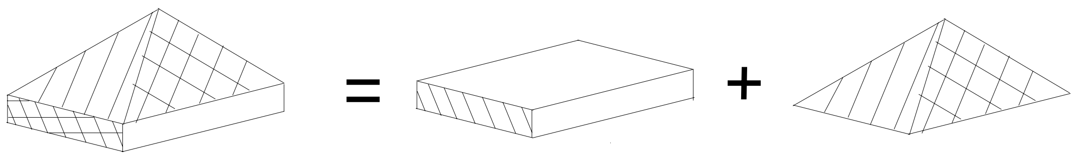
Your animal waste pile will most likely be a complex shape for which a volume formula is not readily available; therefore, you cannot use a simple formula to calculate your amount of animal waste. Instead, contour and break down the complex pile shape into an imaginary group of simple shapes (e.g., cones, rectangular boxes). The volume of each simple shape can then be computed by adding the volumes of all of the simple shapes (see the common volume equations at the end of this appendix). Make sure your measurement units for all simple shapes are consistent. Two examples of how to simplify a complex shape are provided below.

In Example 1, an animal waste container with an annex becomes two rectangular prisms, each with different heights, lengths, and widths. Each volume is calculated separately (length * width * height), and then added together to get a total volume.



Example 1

In Example 2, a heaped load on a wagon becomes a rectangular prism and a rectangular pyramid, with the top of the rectangular prism in common with the bottom of the pyramid. Each volume is calculated separately (see volume equations at the end of this appendix), and then added together to get a total volume.



Example 2

When prism ends do not form a perfect shape, or where the dimension is not uniform along the end, take an average for the dimension when calculating volumes. Sometimes it is necessary to imagine moving animal waste around to form a measurable shape. Although this decreases the accuracy of the volume calculation, it makes it easier to compute the volume.

You will probably need to convert your estimated volume of animal waste (in cubic feet or gallons) to units that match your animal waste application rates (in gallons or tons per acre). Converting animal waste volume to weight requires you to know the bulk density of the animal waste, which you can determine by weighing a unit volume of animal waste and dividing the weight by the volume (see Appendix J for more details on determining the bulk density of your animal waste).

Using Example 1 above, you measure your container and find one section of its inside dimensions to be 12 feet long, 5 feet wide, and 1 feet deep, while the other section is 3 feet long, 5 feet wide, and 0.5 feet deep. The total volume is:

$$\text{Volume (ft}^3\text{)} = [(12 \text{ ft}) \times (5 \text{ ft}) \times (1 \text{ ft})] + [(3 \text{ ft}) \times (5 \text{ ft}) \times (0.5 \text{ ft})] = 67.5 \text{ ft}^3$$

Next, determine the bulk density of your animal waste. If your 5-gallon bucket (which has a volume of 2/3 cubic foot) weighs 5 pounds empty and 37 pounds filled, your density is:

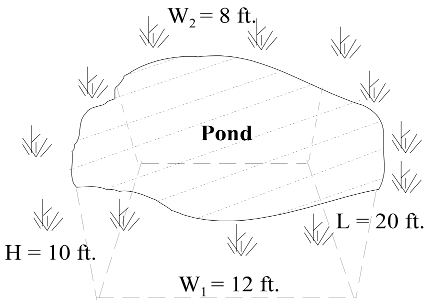
$$\text{Density} = (37 \text{ lb} - 5 \text{ lb}) / (2/3 \text{ ft}^3) = 48 \text{ lb/ft}^3$$

Therefore, your total animal waste in tons is:

$$\text{Total Animal Waste (tons)} = (67.5 \text{ ft}^3 \times 48 \text{ lb/ft}^3)/(2{,}000 \text{ lbs/ton}) = 1.62 \text{ tons}$$

Instructions for Calculating Liquid Animal Waste

Ponds, basins, and pits can be considered inverted piles, and you can therefore use the same techniques to estimate volume in above-ground piles. You can also compute the volume using the dimensions of your basin or by estimating the amount of animal waste removed after emptying your basin. The following example shows how to calculate volume in a basin, assuming the basin is a trapezoidal prism:



Volume = (H x [W_1 + W_2]/2) x L

Volume = (10 x 20/2) x 20 = 100 x 20 = 2,000 ft^3

If you store your animal waste in a constructed tank, use the dimensions of the tank to calculate volume. If the tank is not full, you will need to estimate your “new” height for the tank, that is, how high waste comes to in the tank. Use this new height in your volume calculation.

References

Cooperative Extension Service, University of Maryland System, Agricultural Engineering Department.

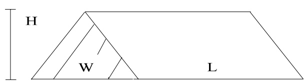
Manure Management. Outreach & Extension, University of Missouri/Lincoln University.

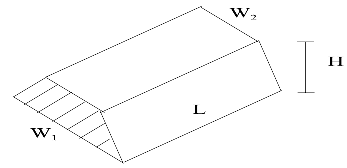
Who To Contact For More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

Common Equations for Calculating Volume

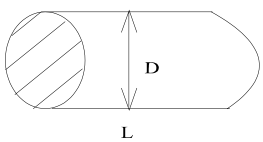
W = Width   H = Height   L = Length   D = Diameter

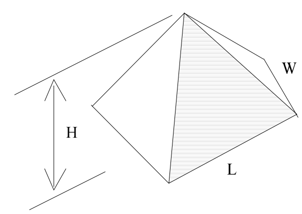




Triangular Prism = (W * H) ÷ 2 * L

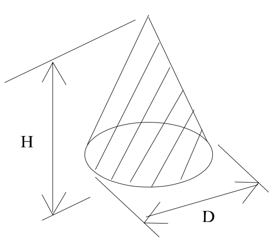
Trapezoid Prism = (H * [W_1 + W_2] ÷ 2) * L

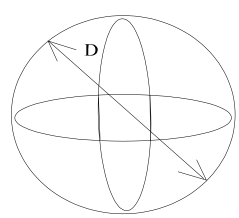




Circular Prism = 0.785 * D^2 * L

Pyramid = W * L * H ÷ 3





Cone = 0.785 x D^2 * H ÷ 3

Sphere = 0.524 * D^3

APPENDIX E - ANIMAL WASTE SAMPLING

Animal waste analysis is a key component of nutrient management. Complete analyses provide critical information about the animal waste composition, including pH and nutrient content. Actual nutrient content of animal waste varies with the type of animal, feed, storage system, and method of animal waste application. You should sample animal waste stored on site each time it is to be removed (for land application on or off site). Sample daily spread operations (if you land-apply daily) several times throughout the year to obtain a good estimate of nutrient content.

Description

Animal waste sampling is relatively simple, but must be done properly for reliable results. The sampling method differs based on the type of animal waste you generate at your farm (e.g., liquid, semi-solid, solid). Animal waste sampling generally consists of two to seven steps, depending on the type of animal waste. Although the number of steps varies based on the physical state of the animal waste, all of the methods rely on collecting a representative animal waste sample for analysis. Where bedding is collected with the animal waste, include both bedding and animal waste in the sample. Also, conduct sampling as close to the time of land application as possible. Specific techniques for gathering poultry litter, liquid animal waste, semi-solid animal waste, and solid animal waste samples are described below; you can use these to help develop sampling procedures at your farm. Remember that you should sample and analyze all animal waste at your farm. Work with your state and local agricultural Cooperative Extension Offices to ensure that you develop the proper procedures for your conditions and animal waste management methods.

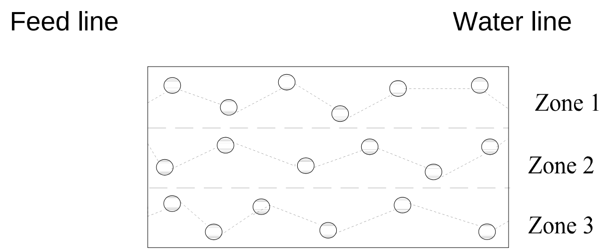
Before sampling, know where the samples are to be shipped, how to pack and ship the sample, and what to use as sample containers. Many laboratories will furnish the proper sample containers for a small charge. Samples should never be collected and shipped in glass bottles, and they should be shipped on wet ice unless otherwise instructed by the laboratory. Contact your state or local agricultural Cooperative Extension Office for a list of laboratories that can perform your analyses. You should also wear gloves at all times, to protect yourself and the sample from contamination.

The test should analyze for such parameters as percentage of dry matter, ammonium-nitrogen, total-nitrogen, phosphorus (P or P_2O_5), and potassium (K or K_2O). Request results in the same units as your calibrated animal waste application system (see Appendix J for more information about calibrating animal waste spreaders and irrigators). For example, if your animal waste application is measured in tons per acre, request that your analysis be reported as pounds of nutrient per ton of animal waste.

Instructions for Collecting Poultry Litter Samples

Poultry litter is a mixture of poultry animal waste and the bedding (e.g., sawdust or rice hull) from houses used to raise broilers, turkeys, and other birds. You will need a clean 5-gallon bucket, a narrow, square-ended spade (or a soil spade), and a 1-quart plastic freezer bag to collect and store your sample. The five steps to collecting a representative poultry litter sample are described below.

Step 1: Mentally divide the poultry house into three zones of equal size. Within each zone, you'll take six cores (i.e., samples) as shown in the diagram below.



Sampling Pattern for Poultry Houses

Step 2: Take the first core within 1 foot of the feed line using your spade. Clear a small trench the width of the spade to the depth of the litter and remove a 1-inch slice, making sure to get equal amounts of litter from all depths. Empty the sample into your bucket.

Step 3: Repeat the process, gathering six cores from each zone, taking your last core within each zone within 1 foot of the water line. Walk the length of the building in each zone in a zigzag pattern taking cores with the spade at random points along your path (as shown in the diagram above). Take a representative number of cores under feeders and waterers. If the bucket becomes full before all 18 samples are taken, dump the contents onto a plastic sheet and continue sampling.

Step 4: After collecting samples from all three zones, crumble and thoroughly mix all of the litter in the bucket. It may be easier to pour the material onto a piece of plastic, or plywood, or into a wheelbarrow to facilitate mixing. Thorough mixing is critical to ensure that the analyzed sample is representative of the entire house.

Step 5: After the litter is well mixed, fill your plastic freezer bag with a subsample (i.e., a small sample) from your composite. Fill the bag only two-thirds full and squeeze the air out before sealing. Keep the sample cool (on ice if possible) until it is shipped.

Instructions for Collecting Liquid Animal Waste Samples

Liquid animal waste is typically stored in tanks, lagoons, or ponds. For tanks, collect only one sample, but collect several subsamples of liquid animal waste to get a representative sample from lagoons and ponds. You will need a clean 5-gallon bucket, a plastic cup, wire, and a long pole to collect liquid animal waste samples from lagoons and ponds. Sample containers are required to collect liquid animal waste samples from all sources. The two steps to collect a representative liquid animal waste sample are described below.

Step 1: For lagoons and ponds, collect several samples from around the shore of the lagoon or pond and mix them together in a clean 5-gallon bucket. You can collect the samples by wiring a plastic cup to the end of a long pole. When taking the sample, turn the cup upside down and push it a few feet below the surface. Then turn the cup right side up and pull out the sample.

If you store your liquid waste in tanks, your tanks must be well agitated before sampling. Often the only practical time to do this is as you are pumping the animal waste into your spreader.

Step 2: Fill a sample container with your sample, making sure to leave 2 inches of air space. Tightly seal the container and keep cool (on ice if possible) until it is shipped.

Instructions for Collecting Semi-Solid Animal Waste Samples

Collecting a representative sample of semi-solid animal waste is best done using a simple sampling device. You will need a 2-inch PVC pipe, nylon rope, a rubber ball, a dowel, a clean 5-gallon bucket, and sample containers. The seven steps to collecting a representative semi-solid animal waste sample are described below.

Step 1: Get a length of 2-inch PVC pipe long enough to reach well into your animal waste storage facility. Cut a notch 2 inches long and 1/4 inch wide at one end of the pipe. Cut a length of nylon rope 2 feet longer than the PVC pipe and tie a knot at one end. Drill a hole through a 2.5 inch rubber ball. Thread the rope through the ball until it is snug against the end knot. Tie a second knot to hold the ball at the end of the rope. Thread the rope through the PVC pipe and pull it until the ball plugs the end of the pipe. Slip your end of the rope into the notch and tie a knot; this will create a “latch” to keep the pipe sealed after you collect the sample. Tie a short dowel to the free end of the rope to serve as a hand grip. Cut a length of 1-inch PVC pipe and seal one end. Use this pipe to push samples out of the tube.

Step 2: With the ball sealing the end of the pipe, push the pipe through the top layer of animal waste to form a sample hole.

Step 3: Release the rope from the notch so that the ball dangles freely from the end of the pipe. Push the pipe into the sample hole in the animal waste crust. Make sure the ball does not block the pipe opening.

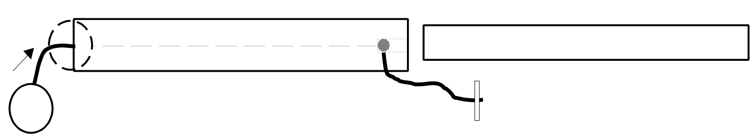
Step 4: Ease the pipe back slightly and pull the rope until the ball seals the end of the pipe. Slip the rope in the notch to anchor the ball in place and withdraw the pipe.

Step 5: Pour the sample into a clean 5-gallon bucket. You may need the 1-inch PVC pipe to force the sample from the pipe. Two people will need to operate a long pipe. To avoid backwash, keep the bottom of the pipe lower than your end.

Step 6: Repeat this process at several locations around the pit.

Step 7: Mix samples thoroughly in the bucket, then fill your sample container with the mix, leaving 2 inches of air space. Tightly seal the container and keep the sample cool (on ice if possible) until it is shipped.

A diagram of the sampling apparatus is shown below.



Sample Apparatus for Semi-Solid Animal Waste

Instructions for Collecting Solid Animal waste

Collecting a representative sample of solid animal waste is best done using a simple sampling device. You will need thin-walled metal tubing (1-inch diameter), a drill, a dowel or short metal rod, a clean 5-gallon bucket, and sample containers. The four steps to collecting a representative solid animal waste sample are described below.

Step 1: Cut a 3-foot length of thin-walled metal tubing and sharpen the bottom edge. Near one end, drill through the tubing and slide in a dowel or short metal rod to make a handle. Cut a 4-foot length of broomstick to force samples from the tube.

Step 2: Push and twist the tubing all of the way into the animal waste pile. Use the broomstick to push the animal waste into a clean 5-gallon bucket.

Step 3: Repeat Step 2 at several random locations around the pile. It is recommended that the more samples the better, so try to get at least 20 samples.

Step 4: Mix samples in the 5-gallon bucket, and fill the sample container with the mix, leaving 2 inches of air space. Tightly seal the container and keep the sample cool (on ice if possible) until it is shipped.

Animal Waste Sample Analyses

Contact your state or local agricultural Cooperative Extension Office for a list of available laboratories that can analyze your animal waste samples. Some Cooperative Extension Offices may even provide free analysis (e.g., in Maryland).

Label, package, and ship your samples to your contracted laboratory. The laboratory should be able to provide their proper protocol for packaging and shipping samples.

Your animal waste sample is typically analyzed for the following constituents:

- Nitrogen;
- Phosphorus;
- Potassium;
- pH;
- Moisture content;
- Calcium;
- Manganese;
- Magnesium;
- Sulfur;
- Zinc; and
- Copper.

The first step in interpreting analytical results of an animal waste test is to check the units used to report the results. They may be reported as percent nutrient (%) or parts per million (ppm), or, on rare occasions, on a dry-weight basis. (Most animal waste is measured on a wet-weight [i.e., as-is] basis.) The phosphorus and potassium may be reported on an elemental basis (P and K) rather than the phosphate (P_2O_5) and potash (K_2O) basis, which is typical of fertilizers. You will need to convert your animal waste test results into the proper fertilizer units for calculating your animal waste application rate.

Animal waste is an excellent fertilizer if it is spread uniformly on a field and at the proper rate. A pound of animal waste phosphate or potash has a nutrient value equivalent to that of commercial fertilizer. Although it has a value as a fertilizer, typically 50 to 80% of the total nitrogen applied is available to crops.

References

MU Extension, University of Missouri-Columbia. Sampling Poultry Litter for Nutrient Testing.

Cooperative Extension Service, University of Maryland System. Manure Analysis Instruction Sheets.

Who to Contact For More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX F - SOIL SAMPLING AND TESTING

The nutrient status of the soil is one of the most important components of a nutrient management plan. A soil test is a laboratory procedure that measures the plant-available portion of soil nutrients. This measurement is used to predict the amount of nutrient or nutrients that will be available during the growing season. Soil test results form the basis for nutrient recommendations. Traditional soil tests include tests for pH, phosphorus, potassium, nitrogen, soil organic matter, and electrical conductivity. You should sample each field area where animal waste nutrients are to be applied. If different field areas have different soil types, past cropping histories, or different production potentials, you should sample and manage these areas separately. You can use soil test results to characterize soil conditions and to determine the agronomic nutrient application rate (see Appendix I) for animal waste application.

Description

Soil sampling determines the average nutrient concentration in a field, and allows you to measure nutrient variability in the field. When you know the variability, you can adjust the fertilizer application rates to more closely meet the supplemental nutrient needs of a crop, which can increase crop yield, reduce commercial fertilizer costs, and reduce environmental risk.

Send all samples to an accredited laboratory for analyses. An accredited laboratory is one that has been accepted in one or more of the following programs:

- State-certified programs;
- The North American Proficiency Testing Program (Soil Science Society of America); and
- Laboratories participating in other programs whose tests are accepted by the Land Grant University in the state in which the tests are used as the basis for nutrient application.

The analytical results from a soil test extraction are relatively meaningless by themselves. You and/or your Certified Nutrient Management Specialist must interpret soil nutrient levels in terms of the soil's ability to supply the nutrients to crops. Most soil test laboratories use qualitative terms such as "low," "medium or optimum," and "high or very high," which are related to quantities of nutrients extracted, to label the results.

Soil testing is a chemical evaluation of the nutrient-supplying capability of a soil at the time of sampling. Poor soil-sampling procedures account for more than 90% of all errors in fertilizer recommendations based on soil tests. The test is only as good as the sample, so you must handle the sample properly for it to remain a good sample. A testing program can be divided into four steps: 1) taking the sample, 2) analyzing the sample, 3) interpreting the sample analyses, and 4) making the fertilizer recommendations.

Take samples as close as possible to planting or to the time of crop need for the nutrient, approximately two to four weeks before planting or fertilizing the crop. It usually takes one to three weeks from the time you sample for you to receive the results. Very wet, very dry, or frozen soils will not affect results, but obtaining samples during these climatic conditions is very difficult. Do not sample snow-covered fields because the snow makes it difficult to recognize. Avoid unusual areas in the field because your sample may not be representative.

You may need to sample once every year and fertilize for the potential yield of the intended crop, especially for mobile nutrients. Whether you need an analysis of a nutrient depends on such things as mobility in the soil and the nutrient requirements of the crop. Having an analysis performed for every nutrient each year is not necessary, although EPA requires that, at a minimum, Large CAFOs should sample soil at least once every five years.

Collect soil samples from each field at least once during each crop rotation cycle, keeping a record of the results for each field to evaluate long-term trends in nutrient levels. Work with your state and local agricultural Cooperative Extension Office to ensure that you develop the best procedures for your conditions and animal waste management methods.

Instructions for Collecting Soil Samples

Below is a set of sampling instructions that you can use to help you develop sampling procedures at your farm. You will need a soil auger or probe (a shovel or spade can be used for shallow samples), a ruler, several 5-gallon buckets for compositing samples, some plastic sheeting, and soil collection bags. Be sure all of your equipment is clean so as not to contaminate any of your samples.

Avoid unusual areas such as eroded sections, dead furrows, and fence lines when sampling. If your sample area contains various topography, subdivide it into relatively uniform areas (i.e., sampling units). Omit small units from sampling since they are probably not treated differently from adjacent units. Sampling units should be approximately 20 acres in area, though some units may be bigger and some smaller.

<u>Number of Subsamples</u>

Collect one sample for each sample unit. (Note that if you collect samples at different depths, such as for nitrogen samples, you will have more than one sample per unit; you will have one sample, per depth, per unit.) Within each sampling unit, take soil samples from several different locations (at the same depth) and mix these subsamples into one composite sample for the unit for a given depth. The number of subsamples you take depends on the size of the unit. You can use the chart below as guidance.

Field Size (acres)	Number of Subsamples
Fewer than 5	15
5 to 10	18
10 to 25	20
25 to 50	25
More than 50	30

Source: Soil Sampling, University of Idaho.

If you sample several units, this guidance may be impractical and unrealistic because of the time required to take the recommended samples. You need to collect a minimum of 10 subsamples from each unit to obtain a representative sample. Your composite sample for the unit should be at least 1 pint in size (approximately 1 pound).

This guidance is also more applicable to surface (i.e., tillage layer) samples. If you take samples at greater depths, take at least 10 or more subsamples at a given depth at random within the sampling unit.

Sampling Depth

The depth at which you should sample depends on your crop, cultural practices, tillage depth, and nutrients to be analyzed. You need surface soil samples for all crops because fertilizer recommendation for all nutrients (except nitrogen) are based on the crop and soil tests from the surface samples. Typically, surface samples are used for determining pH, lime need, organic matter, phosphorus, potassium, sulfur, and zinc. The tillage layer is considered to be the 0-to-6- or 0-to-8-inch depth. Sampling deeper than the tillage layer for these parameters can result in inaccurate results.

When sampling for mobile nutrients such as nitrogen and boron, take samples by 1-foot increments to the effective rooting depth of the crop, which may be 5 to 6 feet for some crops. Therefore, you will have five or six composite samples for the sampling unit (not including your surface sample). Effective rooting depth for some common crops are listed below. You will need subsurface soil samples for these nutrients because they leach into the subsoil. Collect these samples separately from your surface samples.

Crop	Depth (feet)
Cereals (wheat, barley, oats)	5 to 6
Corn	5 to 6
Alfalfa, rapeseed	4 to 5
Hops, grapes, tree fruits	4 to 5
Sugarbeets	2 to 3
Peas, beans, lentils, onions, potatoes, mint	2
Vegetable seed	1 to 1.5

Source: Soil Sampling, University of Idaho.

Sample Collection

Collect the appropriate number (at the appropriate depth) of samples in your bucket, one unit at a time. Take all subsamples randomly from the unit, ensuring that you are getting a representative distribution of samples. Zig-zag through the unit, staying away from the unusual areas as described above. Scrape away any surface residues and mix the sample to break up the soil aggregates. After you have collected all of your subsamples, stir your composite at least 50 times and spread out the sample on a piece of plastic or plywood. Fill your soil bag with 1 pint of soil per unit, discarding the rest of the soil from the unit. Repeat the collection process for each unit and for each depth.

Sampling Handling

Keep moist soil samples cool at all times during and after sampling. Samples can be refrigerated or frozen for extended periods of time. If samples cannot be refrigerated or frozen soon after collection, air-dry them or take them directly to the testing laboratory. Air-dry by spreading the entire sample from a given unit in a thin layer on a plastic sheet, breaking up any clumps, and spreading the soil in a layer about 0.25 inch deep. Dry at room temperature, using a fan (if available) for more rapid drying. When the soil samples are dry, again mix the soil thoroughly, breaking up any large clumps. Take about 1 pint of well-mixed soil from the sample and place it in a soil sample bag or other container. When sending samples to your laboratory, be sure to include which nutrients you want to have analyzed, your last crop grown, and future cropping plans.

Interpreting results

Soil-testing laboratories use different test methods, which may influence results and subsequent recommended agronomic nutrient application rates. Adequate soil nutrient levels vary depending on plant species. Soil test results can be grouped into broad categories that describe the relative crop availability for a given nutrient: low, medium, optimum, and excessive. These categories are described below.

- Low: The nutrient content in the soil is inadequate for optimum growth. Additional nutrients are needed for optimal crop growth.

- Medium: The nutrient content in the soil may or may not be optimum for growth. Additional nutrients may be needed for optimal crop growth.

- Optimum: The nutrient content in the soil is adequate for optimum growth of most crops. Additional nutrients may not be needed for optimal crop growth.

- Excessive: The nutrient content in the soil is more than adequate for optimum growth of most crops. No additional nutrients should added. Additional nutrients may cause excess nutrient leaching or eroding from crop fields into water bodies.

References

Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. Guidelines for Soil Sampling. G91-1000-A, February 1991.

Mahler, R.L., and T.A. Tindall. "Soil Sampling," Bulletin 704 (Revised). University of Idaho, Cooperative Extension System, August 1997.

Maryland Cooperative Extension, University of Maryland College Park/Eastern Shore. Soil Sampling Procedures for Nutrient Management. March 1999.

Oregon State University Extension Service. Soil Test Interpretation Guide, EC 1478, August 1999.

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX G - LEACHING INDEX

Tools such as the Soil Nitrogen Leaching Index have been developed to assist field staff, watershed planners, and land users in evaluating various land forms and management practices for potential risk of nitrogen and phosphorus movement to water bodies. The vulnerability ratings of the Leaching Index (i.e., inches of water infiltrating below the 1- meter root zone) address the ability of soluble nitrogen to move below the crop root zone and into groundwater.

The material contained in this appendix should be used for your informational purposes only. Specific leaching index calculations should be done by NRCS, your local extension, or a certified nutrient management planner.

Description

The Leaching Index (LI) is a simple index of potential leaching based on average annual percolation and seasonal rainfall distribution. It is important in determining the amount of nitrate nitrogen leached. The LI considers the saturated hydraulic conductivity and storage capacity of individual soils (based on various regions of the country), the average annual rainfall, and the seasonal distribution of that rainfall. It does not look at the leaching potential of specific nutrients, but rather the intrinsic probability of leaching occurring if nutrients are present and available to leach.

Instructions for Calculating Your Leaching Index

The LI for local areas is in the USDA/NRCS Field Office Technical Guide (FOTG), Section II-3, or you can calculate it using the following equations:

$$LI = P \ x \ SI$$

where:

$$P = \frac{(p - 0.4s)^2}{p + 0.6s}$$

where:

p	=	annual precipitation
s	=	(1,000/curve number) - 10

$$SI = \left(\frac{2PW}{p}\right)^{1/3}$$

where:

PW = fall and winter precipitation when crop growth is minimal, usually the sum of precipitation during October, November, December, January, and February

An LI below 2 inches would indicate that soluble nitrogen would likely not leach below the root zone, whereas an LI between 2 and 10 inches indicates that soluble nitrogen may leach below that zone. You should consider nutrient management practices and techniques, such as pre-sidedress nitrate nitrogen testing (which measures soil nitrate during the growing season rather than prior to it) and use of a nitrification inhibitor.

An LI greater than 10 inches indicates that soluble nitrogen leaches below the root zone. You should use an intense nitrogen management plan to minimize nitrate nitrogen movement. This would include careful management of applied nitrogen, precise timing to match crop utilization, conservation practices that restrict water percolation and leaching, and covering crops to capture and retain nutrients in the upper soil profile.

References

USDA/NRCS Field Office Technical Guide.

Core4 Conservation Practices, August 1999.

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX H - PHOSPHORUS INDEX

The Phosphorus Index has been developed to assist field staff, watershed planners, and land users in evaluating various land forms and management practices for potential risk of nitrogen and phosphorus movement to water bodies. The site rating of the Phosphorus Index (i.e., low, medium, high, very high) identifies sites where the risk of phosphorus movement may be relatively high when compared to other sites.

The material contained in this appendix should be used for your informational purposes only. Specific phosphorus index calculations should be done by NRCS, your local extension, or a certified nutrient management planner.

Description

The Phosphorus Index (PI) is a simple assessment tool that examines the potential risk of phosphorus movement to waterbodies based on various landforms and management practices. The PI identifies sites where the risk of phosphorus movement may be relatively higher or lower than other sites. It considers soil erosion rate, runoff, available phosphorus soil test levels, fertilizer and organic phosphorus application rates, and methods to assess the degree of vulnerability of phosphorus movement from the site. A weighting procedure includes the various contributions each site characteristic may have.

Instructions for Calculating Your Phosphorus Index

The PI uses eight characteristics, as presented in the following table, to obtain an overall rating for a site. Each characteristic is assigned an interpretive rating with a corresponding numerical value: LOW (1), MEDIUM (2), HIGH (4), or VERY HIGH (8), based on the relationship between the characteristic and the potential for phosphorus loss from a site. Suggested ranges appropriate to each rating for a site characteristic are then assigned. Each of the characteristics in the PI has also been given a weighting factor that reflects its relative importance to phosphorus loss. For example, erosion (weighting factor = 1.5) is generally more important to phosphorus loss than phosphorus fertilizer application method (weighting factor = 0.5). The weighting factors used are currently based on the professional judgment of the scientists that developed the PI; they are not derived directly from field research with the PI. Contact your state or local conservation agency for modified weighting factors, which are based on local soil properties, hydrologic conditions, and agricultural management practices.

Site Characteristic (weighting factor)	**Phosphorus Loss Rating (value)**				
	None (0)	**Low (1)**	**Medium (2)**	**High (4)**	**Very High (8)**
Soil erosion (1.5)	Not applicable	<5 tons/acre	5-10 tons/acre	10-15 tons/acre	>15 tons/acre
Irrigation erosion (1.5)	Not applicable	Infrequent irrigation on well-drained soils	Moderate irrigation on soils with slopes < 5%	Frequent irrigation on soils with slopes of 2-5%	Frequent irrigation on soils with slopes > 5%
Soil runoff class (0.5)	Not applicable	Very low or low	Medium	High	Very high
Soil test P (1.0)	Not applicable	Low	Medium	High	Excessive
P fertilizer rate (lb P2O5/acre) (0.75)	None applied	<31	31-90	91-150	>150
P fertilizer application method (0.5)	None applied	Placed with planter deeper than 5 cm	Incorporate immediately before crop	Incorporate > 3 months before crop or surface applied < 3 months before crop	Surface applied > 3 months before crop
Organic P source application rate (lb P2O5/acre) (1.0)	None applied	<31	31-90	91-150	>150
Organic P source application method (1.0)	None	Placed with planter deeper than 5 cm	Incorporate immediately before crop	Incorporate > 3 months before crop or surface applied < 3 months before crop	Surface applied > 3 months before crop

Source: Soil Testing for Phosphorus, USDA, April 1998.

For each of the eight characteristics, multiply the characteristic weighting factor by your phosphorus loss rating value, and sum the totals. For example, if your soil erosion is medium and your irrigation erosion is high, then your overall site characteristic score for soil erosion is 3 (1.5 * 3) and for irrigation erosion is 6 (1.5 * 4). Calculate your site characteristic score for the remaining six characteristics and the sum them (i.e., 3 + 6 + remaining scores).

This sum total is your phosphorus index for your site. Use the table below as guide to your phosphorus index.

Phosphorus Index for Site	Generalized Interpretation of Phosphorus Index for Site
<8	LOW potential for P movement from the site. If farming practices are maintained at the current level, the probability of an adverse impact to surface waters from P losses at this site is low.
8 - 14	MEDIUM potential for P movement from the site. The chance for an adverse impact to surface waters exists. Some remedial action should be taken to lessen the probability of P loss.
15 - 32	HIGH potential for P movement from the site and for an adverse impact on surface waters to occur unless remedial action is taken. Soil and water conservation as well as P management practices are necessary to reduce the risk of P movement and water quality degradation.
> 32	VERY HIGH potential for P movement from the site and for an adverse impact on surface waters. Remedial action is required to reduce the risk of P loss. All necessary soil and water conservation practices, plus a P management plan, must be put in place to avoid the potential for water quality degradation.

Source: Soil Testing for Phosphorus, USDA, April 1998.

References

USDA/NRCS Field Office Technical Guide.

Core4 Conservation Practices, August 1999.

U.S. Department of Agriculture. Soil Testing for Phosphorus, April 1998.

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX I - AGRONOMIC NUTRIENT APPLICATION RATE

Good nutrient management includes proper land application of animal wastes. To do this, determine the most appropriate rate at which your animal waste should be applied. Calculate this application rate using results from your soil and animal waste analyses, crop nutrient recommendations, and land availability. It is important to consider all of these factors when calculating your nutrient application rate to reduce commercial fertilizer costs, reduce potential for crop damage, and reduce environmental impact.

Description

Animal waste nutrient application rates should be based upon Land Grant University guidance and site-specific test results. You should consider current soil test results, nutrient credits from previous legume crops and animal waste applications, crop yield goals, and other pertinent information when determining your nutrient balance, which is used to calculate your application rate.

Base your application rate on realistic yield goals. You can calculate an appropriate application rate, or agronomic rate, using the nutrient availability of the animal waste and the crop requirement for the nutrient having the highest nutrient need (nitrogen or phosphorus). Most state guidelines/policies allow animal waste applications at rates sufficient to meet, but not to exceed the nitrogen needs of agronomic crops, which typically results in over application of phosphorus. However, in areas with high soil phosphorus levels, animal waste should be applied at rates sufficient to meet, but not to exceed the phosphorus needs of agronomic crops.

To calculate your nutrient application rate you need to perform a nutrient balance to determine whether animal waste nutrient spreading is necessary. To do this, first determine your crop nutrient needs, accounting for the nutrients currently available in your soil (as determined in your soil analyses) and from nitrogen credits. Next, determine how many gallons (or tons) of animal waste you collect between each land application (see Appendix D for more information on estimating animal waste volumes). Then, using the results of your nutrient animal waste analysis (see Appendix E), calculate the amount of nutrients available each year from your animal waste. Now you can calculate the amount of animal waste needed to meet your nutrient needs, which is done by dividing your crop nutrient need by your nutrient animal waste analysis for a few key nutrients (e.g., nitrogen and phosphorus). These steps are described in more detail below.

Performing A Nutrient Balance

To determine your agronomic nutrient application rate, you need to perform a nutrient balance for your crops. The nutrient balance accounts three components needed to calculate an application rate: 1) the nutrients your crops need, 2) the nutrients available to your crops from prior nutrient applications (i.e., nutrient credits), and 3) the nutrients available from your animal waste.

Most crop nutrient requirements and nutrient credits are calculated from many years of field research. There is no “real time” method available for calculating your crops’ nutrient requirement or the nutrients available at any one time. Rather, both components are based on past performance for your climate and soil condition.

A nutrient budget is a method for matching the nutrient needs of your crop with your available nutrients. It can easily determine if there is a gross imbalance between the nutrients that are available and the amount required and can be used to calculate a nutrient addition rate.

There are two methods for calculating a nutrient budget. The first is based on a soil test analysis and crop nutrient recommendation as given by an agronomic specialist (e.g., USDA, land grant university). The nutrient requirement of your crop is determined from historical field research for your soil and climate. The nutrient credits are derived from analysis of soil and historical animal waste spreading data. This method is EPA's preferred method because it takes into account your local climate and soil conditions. Typical crop nutrient requirements can be obtained from USDA and state agricultural Cooperative Extension Offices. Some states have even developed agronomic plant nutrient recommendations based on soil tests and yield goals for the major agronomic crops grown in that state.

The second method is based on the balance between nutrients supplied to the crop and nutrients removed by the crop. You need to know the crop for which you are planning a nutrient budget. Nutrient budgets can be calculated for a single crop or over the entire crop rotation. You need to know your expected crop yield based on realistic soil, climate, and management parameters. Yield expectations can be calculated from historical records, soil productivity tables, or local research.

Estimating the Nutrients Removed by the Crop

The nutrients removed by the crop can be used to represent your nutrient crop need when it is not available from other sources. When a crop is harvested and removed from the field, the nutrients in that crop are also removed. These removed nutrients represent a net loss to the soil. Other losses, such as erosion and runoff, and leaching can occur and must be estimated if you are trying to maintain a constant level of nutrients in your field. The USDA/NRCS Agricultural Waste Management Field Handbook, Table 6-6, can be used to estimate nutrient content in harvested crops. This handbook can be found on the Internet at **http://www.ftw.nrcs.usda.gov/awmfh.html**. Chapter 11 of this handbook can be used to estimate nitrogen nutrient losses from the field system. Use the following form to calculate the nutrients removed by your crop.

Step 1: Yield (units of measure/acre) * Unit weight (lbs) = pounds crop material harvested

______________________ * _____________ = _______________ lb/acre

Step 2: Nutrient content of harvested material (refer to Table 6-6 of the Agricultural Waste Management Field Handbook)

% N = ________ % P = _________ % K = ________

Step 3: Crop nutrient Content (multiply results in Step 1 by results in Step 2)

N = _____ lb/acre * ______ %N P = _____ lb/acre * _____%P K = _____lb/acre * _____%K

N = _______lb/acre P = ________ lb/acre K = _______ lb/acre

Step 4: Convert to fertilizer equivalent units

N =N lb/acre P_2O_5 = P lb/acre * 2.29 K_2O = K lb/acre * 1.2

N = ______ lb/acre P_2O_5 = ______ lb/acre K_2O = ______ lb/acre

Source: Core4 Conservation Practices, August 1999.

Estimating Nitrogen Credits

Nitrogen is a mobile nutrient and exists in the soil and plants in many forms. It is stored in the soil's organic matter and released as the organic matter decomposes. This nitrogen is available to crops during this time and should be accounted for in performing your nutrient balance. There are at least four groups of nitrogen credits that you need to account for: 1) legume nitrogen credits from your previous crop, 2) residual nitrogen from previous manure applications, 3) irrigation water nitrate nitrogen, and 4) other sources. These are described below.

- Legume Nitrogen Credits - Legumes can produce, through atmospheric fixation, enough nitrogen to meet their nutrient requirements. When the legume is harvested, organic nitrogen is mineralized, releasing available nitrogen to the following crop. Refer to your local extension information for the legume nitrogen credits.

- Nitrogen residual from previous manure applications - Organic nitrogen mineralizes according to a decay series which is specific for each manure type and composition. This concept recognizes the gradual mineralization of organic nitrogen over several years. Refer to your local mineralization rates to determine the residual release of nitrogen.

- Irrigation Water Nitrate Nitrogen - Irrigation water, especially from shallow aquifers, contain some nitrogen in the form of nitrate nitrogen. To calculate the amount of nitrogen applied with irrigation water, determine the concentration of nitrate nitrogen in water (in mg/L). The application amount will equal the nitrate nitrogen concentration multiplied by the volume (in acre-inches) times 0.23 to calculate pounds of nitrate per acre.

- Other Nitrogen Credits - Other credits come from atmospheric deposition from dust and ammonia in rainwater. This value is recorded by weather stations and can obtained from the National Atmospheric Deposition in Fort Collins, Colorado. The atmospheric deposition can range from a few pounds per acre per year to over 30 pounds per acre per year.

Use the following chart to calculate your nitrogen credits.

A.	Legumes Credits from Previous Crop	_____ lb/acre
B.	Residual from Previous Animal Waste Applications	_____ lb/acre
C.	Irrigation Water Nitrate Nitrogen	_____ lb/acre
D.	Others (atmospheric deposition, other fertilizer applications)	_____ lb/acre
Total Nitrogen Credits (Sum of A through D)		_____ lb/acre

Calculating the Number of Pounds of Each Nutrient Available During Land Application

To calculate the number of pounds of each nutrient that is available during land application, you need to know how much animal waste you produce (see Appendix D) and the nutrients contained in it (see Appendix E). Using your animal waste sampling results, multiply the amount of animal waste in storage (or available for application) by the concentration of nutrients found in your animal waste, as shown below.

Nutrient	Amount of Animal waste Available (gal or tons)		Concentration of Nutrient in Animal waste Analysis (lb/gal or lb/ton)		Pounds of Nutrient Available
Nitrogen		x		=	
Phosphorus (P2O5)		x		=	
Potassium (K2O)		x		=	

Source: Iowa State University, 1995.

After calculating the pounds of nutrients available, you need to correct for the nitrogen that is lost to the air during application. (It is assumed that there are no losses of phosphorus or potassium during application.) The remaining amount is the amount of nitrogen that will remain after spreading. To do this, multiply your pounds of nitrogen available (from the above chart) by the correction factor below that best describes your animal waste application method, and then plug that factor into the following form.

- Direct injection - 0.95
- Broadcast and incorporate within 24 hours - 0.95
- Broadcast and incorporate after 24 hours - 0.8
- Broadcast, no incorporation - 0.7

If you use a combination of application methods, you will need to account for this difference in the total pounds of nitrogen available, using the appropriate ratio of pounds available with the appropriate correction factor.

Pounds of Nitrogen Available		Correction Factor		Nitrogen Remaining after Application Loss (lbs)
	x		=	

Source: Iowa State University, 1995

The result is the nitrogen remaining after application losses; however, only 50 to 80% of the organic nitrogen will be available to plants the first year after spreading. The percentage available depends on the type of animal waste spread. Beef and dairy animal waste has approximately 50% available, while poultry waste has approximately 80% available. Next, multiply your nitrogen amount by your factor (e.g., 0.50 or 0.80) using the following chart. The result is the net usable nitrogen in your animal waste (in pounds).

Pounds of Nitrogen Remaining after Application Loss		Percent of Nitrogen Available (as a decimal)		Net Usable Nitrogen in Animal Waste (lbs)
	x		=	

Source: Iowa State University, 1995

Account for the nitrogen credits by adding the total estimated nitrogen credits to the net usable nitrogen in animal waste to calculate the total nitrogen available sources.

To calculate the usable amount of each nutrient available during application, divide the total usable amount of nutrient in animal waste (using the adjusted amount for nitrogen) by your available volume of animal waste, to calculate a rate in pounds of nutrient per gallon of animal waste, or pounds of nutrient per ton of animal waste.

Instructions for Determining Animal Waste Volume to Apply

After calculating your nutrient needs, total pounds of nutrients available and the pounds of nutrients available to plants in each gallon (or ton) of animal waste spread, you have determined your nutrient balance and can calculate the amount of animal waste to apply to your crops. For each nutrient, divide your net nutrient needs (calculated or estimated from published rates) by the usable nutrient amount available (in pounds per gallon or pounds per ton) to calculate the amount of animal waste you need to apply. Do this for both nitrogen and phosphorus. You will base your application rate on whichever nutrient requires less animal waste. Next, divide your total volume of animal waste needed by your land area (in acres) to calculate your animal waste application rate (in gallons per acre or tons per acre).

References

U.S. Department of Agriculture. CORE4 Key Conservation Practices, August 1999.

Iowa State University, University Extension. Land Application for Effective Manure Nutrient Management, Pm-1599, October 1995.

Wolkowski, Richard P. A Step-by-Step Guide to Nutrient Management. Nutrient and Pest Management Program, A3568.

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX J - CALIBRATING ANIMAL WASTE SPREADERS AND IRRIGATORS

Animal waste should always be applied uniformly and at a rate consistent with nutrient demand. Although many equipment options exist, there are basically three general methods of application: subsurface application, irrigation, and surface application. The method of application, however, is generally dictated by the form of the animal waste (i.e., solid, semi-solid, liquid). For example, solid animal waste is generally best applied using a surface spreader or subsurface system. Liquid animal waste is applied by pump and liquid spreader, subsurface, or irrigation system. Semi-solid animal waste can be handled as a solid or a liquid; therefore, it can be applied with a surface spreader, liquid spreader, subsurface, or irrigation system. This appendix discusses calibration techniques for surface application, subsurface application, and irrigation.

Description

Animal waste spreader calibration is a key component of nutrient management. To properly calibrate your system, you will need to know your animal waste application rate (see Appendix I).

You can perform animal waste spreader calibration using two direct methods: load-area and weight-area. Both methods require measuring the amount of animal waste applied to the soil under different conditions. The load-area method involves measuring the amount of animal waste in a loaded spreader and then calculating the number of spreader loads required to cover a known land area. Subsurface application calibration should be done using the load-area method because soil-injected animal waste cannot be collected. The weight-area method requires weighing animal waste spread over a small surface and computing the quantity of animal waste applied per acre. You can measure the application rates for irrigation systems using the area of your liquid storage.

Animal waste should be collected after spreading, if possible. If calibrating using a large tarp or plastic sheet, then you can easily recollect the test volume. If the animal waste is spread on a known area, such as 500 or 1000 ft^3, this should be done in a field were the animal waste can be left on the surface.

Your calibration method used depends on the type of animal waste spreader used (e.g., liquid animal waste is best measured with the load-area method, while solid or semi-solid animal waste may be used with either method). Instructions for using load-area calibration and weight-area calibration, as well as for calculating irrigation rates from irrigation systems are provided below.

Instructions for Load-Area Calibration (Solid, Semi-solid, or Liquid Animal Waste)

Use this method when you know your animal waste spreader’s capacity or animal waste weight. This approach works well with a liquid spreader filled to capacity, and is less accurate for box spreaders or other solid application systems where capacity is difficult to estimate.

Overview

1. Measure the capacity of animal waste (tons or gallons) held in the spreader load.
2. Spread a number of identical loads at a constant speed, spreader setting, and overlap.
3. Measure the total area of the spread.
4. Compute the amount of animal waste spread per acre.

Measure the capacity of animal waste (tons or gallons) held in the spreader load.

The capacity must be expressed in units compatible with the units used in the nutrient analysis and recommended application rate. The capacity is sometimes provided by the equipment manufacturer.

Liquid animal waste application is expressed in pounds of nutrient per gallon; the application rate is given in gallons per acre. Spreader capacity is given in gallons of animal waste.

Solid and semi-solid animal waste application is expressed in pounds of nutrient per ton; the application rate is given in tons per acre. Spreader capacity is given in tons of animal waste. Note that the moisture content in animal waste affects the weight. Therefore, the weight capacity of the spreader varies based on the animal waste held. The most accurate method of determining the weight of a load is to actually measure the load using farm scales.

If scales are not available, use the following steps to convert volumetric capacity to weight capacity:

- The manufacturer should supply the volumetric capacity of the spreader in cubic feet. Two capacities are usually provided: heaped load (animal waste piled higher than the sides of the box) and struck load (the volume contained within the box).

- The capacity of older spreaders is sometimes given in bushels; multiply the bushel capacity by 1.24 to determine capacity in cubic feet.

- Next, multiply the volumetric capacity (in cubic feet) by the bulk density of the animal waste (in pounds per cubic foot) and convert it to tons by dividing by 2,000.

- Bulk density depends on the amount of water, solids, and air in the animal waste and can be measured by weighing a known standard volume of animal waste. A 5-gallon bucket has a volume of two-thirds cubic foot and can be used as a standard volume by weighing an empty bucket and recording the weight, filling the bucket with animal waste from the loaded spreader (packed to the same density as in the spreader), weighing the full bucket, and subtracting the empty bucket weight to calculate the animal waste weight in pounds. Next, multiply the animal waste weight by 3, and then divide by 2 to calculate the animal waste bulk density in pounds per cubic foot of volume.

- Multiply the bulk density by the spreader capacity (in cubic feet) to calculate the weight of the spreader load in pounds, and then divide by 2,000 to calculate tons.

- Repeat this procedure at least three times, sampling the animal waste at different places and in different spreader loads.

- Average the results to obtain a representative composite of the animal waste.

Spread a number of identical loads at a constant speed, spreader setting, and overlap.

Spread at least three full loads of animal waste on the field, maintaining the same speed and spreader setting for each load. Try to spread in a rectangle or square for easy calculation.

Measure the total area of the spread.

Place flags at the four corners of the spread area. Measure the width and length between the flags (in feet) using a measuring tape, wheel, or consistent pace. Multiply the width by the length and divide that product by 43,560 to determine the area in acres.

Compute the amount of animal waste spread per acre.

Multiply the number of loads spread by the number of tons (or gallons) per load to determine the total amount of animal waste applied to the area. Divide the total amount of animal waste by the area of the spread (in acres) to determine the application rate in tons per acre (or gallons per acre).

Repeat this procedure for various speeds and spreader settings until the desired application rate is achieved, maintaining a record of the rates found at the different settings. This procedure needs to be repeated for each piece of equipment used to spread animal waste.

Instructions for Weight-Area Calibration (Solid or Semi-solid Animal Waste)

Use this method to estimate solid and semi-solid animal waste application rates.

Overview

1. Select a animal waste collection surface.
2. Secure the collection surface in the field.
3. Spread animal waste over the collection area.
4. Collect and weigh the animal waste.
5. Compute the application rate.

Select a animal waste collection surface.

Select a ground cover that can be used to collect the animal waste. The ground cover can be a cloth or plastic sheet of at least 100 square feet in area. Multiply the length of the sheet by the width to determine the area in square feet. If the animal waste is too liquid, use shallow plastic or metal pans on top of the ground cover, with a minimum area of 1 square foot each. Multiply the pan length by the width to calculate the area of one pan. Multiply the area of the one pan by the number of pans to determine the total collection area in square feet. For handling and cleaning convenience, place a plastic garbage bag inside the pan for each field test so that the bag and animal waste can be discarded, leaving the pan clean. Six or more pans are necessary for a test.

Weigh the ground cover or one pan and record the weights for use as a tare weight in calculations. You can use dirty sheets and pans for multiple tests only after removing major animal waste deposits. Weight dirty sheets and pans before each test so that any animal waste residue is included in the new tare weight.

Secure the collection surface in the field.

Lay out the ground cover, fully extended. Lay the sheet on the ground so that, as the sheet is removed from the field, the animal waste applied over the surface can be collected easily in its folds. If dirty sheets are being used for additional test, turn the dirty side up so that any animal waste residue included in the tare weight is not lost. Use stone, metal, or earth clods to hold down the cover so that the wind does not disturb it. Evenly space pans in a row perpendicular to the spreader’s path. Be mindful of tires, as they can easily crush the pans. Place flags at designated wheel tracks to help avoid pan damage.

<u>Spread animal waste over collection area.</u>

Spread animal waste over and near the ground cover or pans in a pattern similar to that practiced during spreading. With rear outlet spreaders, make three passes: the first directly over the center of the collection area and the second two on each side of and overlapping the first pass. With side outlet spreaders, locate a first pass off of but along one edge of the collection area. Continue with subsequent passes farther away from the collection area and at the intended overlap until animal waste no longer reaches the surface.

In all cases, start spreading animal waste far enough before the collection area to ensure that the spreader is functioning. If a ground cover is folded or a pan is moved during a spread pass, investigate its condition before continuing with the test. Folded edges can be straightened without major loss of accuracy. If more than one-fourth of the surface has moved and did not receive animal waste, conduct the test again with a newly weighed sheet.

<u>Collect and weigh the animal waste.</u>

Remove the weights holding the ground cover in place. Fold the cover and animal waste in short sections from all sides and corners inward, avoiding animal waste loss. A 100-square-foot sheet folded with wet animal waste may weigh as much as 150 pounds and can be difficult to handle; place the folded cover in a feed tub or other container for easier handling. Pans typically weigh less than 5 pounds each and are usually easier to handle.

Select scales that can accurately weigh the type and quantity of animal waste collected (e.g., kitchen scales for pans, spring-tension milk scales, or platform balances for ground covers). The weight indicated on the scale includes the tare weight of the cover or pans. Subtract the tare weight from the indicated weight to determine the net weight of the animal waste collected.

<u>Compute the application rate.</u>

The application rate is based on the method of collection and the units per acre.

Using a ground cover: Divide the net pounds of animal waste collected by the ground cover area to obtain the animal waste application rate in pounds of animal waste per square foot. Multiply that result by 43,560 and then divide by 2,000 to convert to tons per acre.

Using pans: Add the net weights of the animal waste collected in the individual pans to calculate the total animal waste weight collected. Divide the total animal waste weight by the total collection area to obtain pounds of animal waste per square foot. Multiply that result by 43,560 and then divide by 2,000 to convert to tons per acre.

If working with liquid animal waste, make an additional measurement to calculate the weight per gallon of animal waste. Fill a 5-gallon bucket with liquid animal waste similar to that tested. Weigh the bucket of animal waste and subtract the tare weight of the bucket to determine the net weight of 5 gallons of animal waste. Divide the result by 5 to determine the weight in pounds per gallon. Multiply this weight by the number of pans collected. Divide the total animal waste weight by the total collection area to obtain pounds of animal waste per square foot. Multiply that result by 43,560 and then divide by pounds per gallon to convert to gallons per acre.

Instructions for Irrigation System Calibration

Use this method when a direct measure of volume is not available when pumping from a lagoon or animal waste storage. Different methods are used depending on whether you use a traveling gun irrigation system or center pivot irrigation system. Both methods are described below.

Measure surface area of lagoon or storage

Calculate the area (assumed to be a rectangle) by multiplying length (in feet) by width (in feet) to calculate the surface area in square feet. Take these measures at the liquid level and not at the top of the storage. Secure a yardstick or other measuring tool to a wooden stake, and plant the stake in the storage where the wastewater is several feet deep. Start your irrigation system.

If using a traveling gun irrigation system:

Note the starting location of the towed irrigation system and at the same time the liquid level in the storage tank on the yardstick (to the nearest quarter inch). Mark the irrigation nozzle location with a stake; this is considered Depth 1. Record results in inches.

Measure the diameter of the wetted circle from the irrigation nozzle (in feet). It is best if this measure is perpendicular to the direction of travel.

At some later time (at least an hour), note the liquid level in the storage tank again, generally after more than one foot change in depth has occurred. (The greater the change in depth, the more accurate the estimated application rate will be.) This is considered Depth 2. Record results in inches.

Note the location of irrigation nozzle with a second stake at the same time of the second depth measure. Measure the distance between the two stakes (in feet).

Calculate the application rate by multiplying the area by the difference between Depth 1 and Depth 2 (i.e., Depth 1 - Depth 2). Multiply this result by 27,200 (conversion factor). Divide this number by the distance between the two stakes, and divide this result by the diameter of the wetted circle. Your application rate will be given in gallons per acre. Note that this test assumes that your irrigation sprinklers do not overlap when applying. If your sprinklers do overlap, you need to ensure that you account for the overlap when calculating your rate. You can use the spacing between sprinkler pulls or run when calculating your rate.

If using a center pivot irrigation system:

Note the location of the pivot irrigation system and at the same time the liquid level in the storage tank on the yardstick. If possible, measure depth to the nearest quarter inch. Mark the irrigation nozzle location with a stake; this is considered Depth 1. Record results in inches.

When the pivot has completed an entire circle, note the wastewater depth again. This is considered Depth 2. Record results in inches.

Calculate the application rate by multiplying the area by the difference between Depth 1 and Depth 2 (i.e., Depth 1 - Depth 2). Multiply this result by 0.62 (conversion factor). Divide this number by the acres under the pivot, and divide this result by the fraction of the circle your pivot was able to complete. For example, if your pivot completes an entire circle, the fraction is 1. If it only completes 2/3 of the circle, the fraction is 0.667. Your application rate will be given in gallons per acre.

A center pivot is designed for a uniform pumping rate (GPM) and pressure. If this rate and pressure are used for animal waste, you already know how many gallons are applied per time unit and you know how long it take the unit to complete a circle (the ground drive is usually electric). Therefore, you can calculate total gallons without running the system. Then divide by the acres under the system and you have the rate per acre. It is useful to check this periodically, though your rate should not change unless the pump is damaged or worn. If you add fresh water to the mix, then the total gallons of animal waste is reduced by a like amount, but the fact remains that a sprinkler will only put out a set volume at a given pressure.

References

Northeast Regional Agricultural Engineering Service. Fertilizer and Manure Application Equipment, NRAES-57, April 1994.

Maryland Institute for Agricultural and Natural Resources. Fact Sheet: Calibrating Manure Spreaders, Fact Sheet 419.

Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. Manure Applicator Calibration, G95-1267A.

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX K - SOIL LOSS (EROSION)

Calculating Soil Loss

Erosion losses are frequently estimated by the Universal Soil Loss Equation and the Revised Universal Soil Loss Equation (RUSLE). The basic equation is

$$A = R * K * LS * C * P$$

where:

A = estimated average soil loss in tons per acre per year
R = rainfall-runoff erosivity factor
K = soil erodibility factor
L = slope length factor
S = slope steepness factor
C = cover-management factor
P = support practice factor

See the *Agriculture Handbook* (No. 703, USDA, 1997), which describes RUSLE in great detail.

Another factor for soil loss is called the "T value" which stands for "Tolerable Soil Loss." It is not directly used in RUSLE equation, but is often used along with RUSLE for conservation planning.

Soil Loss Tolerance (T)

Soil loss tolerance (T) is the maximum amount of soil loss in tons per acre per year, that can be tolerated and still permit a high level of crop productivity to be sustained economically and indefinitely. EPA encourages alternative approaches that tie the pollutant reductions to “T”, the soil loss tolerance factor. “T” is defined as the maximum amount of erosion at which the quality of a soil as a medium for plant growth can be maintained. T factors commonly serve as objectives for conservation farm planning. These objectives assist in the identification of cropping sequences and management systems that will maximize production and sustain long-term productivity. T factors represent the goal for maximum annual soil loss, in the context of maintaining the long term sustainability goal. This includes maintaining (1) the surface soil as a seedbed for plants, (2) the interface between the air and the soil that allows the entry of air and water into the soil and still protect the underlying soil from wind and water erosion, and (3) the total soil volume as a reservoir for water and plant nutrients, which is preserved by minimizing soil loss.

For more information see *Natural Resources Conservation Service, National Soil Survey Handbook, title 430-VI (Washington, D.C., U.S. Government Printing Office, September 1999).*

APPENDIX L - WINTER SPREADING TECHNICAL GUIDANCE

Interim Final

Technical Guidance
for the
Application of CAFO Manure on Land in the Winter

Water Division
Region 5
United States Environmental Protection Agency

Introduction[1]

Many owners or operators of concentrated animal feeding operations (CAFOs) utilize their manure, litter, and process wastewater (hereinafter "manure") as a source of nutrients for the growth of crops or forage or to improve the tilth of soil. Others dispose of manure on land. The longer manure remains in the soil before plants take the nutrients up the more likely those nutrients will be lost through volitization, denitrification, leaching to subsurface drainage tile lines or ground water, and runoff to surface water. To utilize the greatest fraction of the nutrients in manure, late spring and early summer are the best times for land application. Some CAFO owners or operators apply manure on land in the late fall or winter because crops are not growing, labor is available and, when it is frozen, the soil is able to handle the weight of manure hauling equipment without excessive compaction. Application in the late fall or winter also enables the owner or operator to avoid the cost of the structures that would be needed to store manure through the winter months. From the dual perspectives of nutrient utilization and pollution prevention, however, winter is the least desirable time for land application. Appendix 1 contains an excerpt from the United States Environmental Protection Agency (EPA) (2002) summarizing the literature on the risk that land application in the winter poses to water quality. *See* page 19.

Under regulations that EPA promulgated in 2003, agencies that are authorized to issue National Pollutant Discharge Elimination System permits (hereinafter "states") need to have technical standards for nutrient management which address, among other factors, the times at which CAFOs may apply manure on land (*see* Title 40 of the Code of Federal Regulations, section 123.36). Technical standards are to achieve realistic crop or forage production goals while minimizing movement of nitrogen and phosphorus to waters of the United States. They will form the basis for the nutrient management plans that CAFO owners and operators will implement under 40 CFR sections 122.42 and 412.4.

EPA recognizes certain times during which there may be an increased likelihood that runoff from CAFO land application areas may reach waters of the United States. The times include, among others, when the soil is frozen or covered with ice or snow. Frozen soil will occur in areas where snow or other ground cover is shallow and where prolonged periods of subfreezing air temperatures prevail (United States Army Corps of Engineers 1998). The January normal daily minimum air temperature in EPA Region 5 ranges from minus eight degrees Fahrenheit in the northwest to 22 degrees Fahrenheit in the south. Thus, all areas in the Region are subject to air temperatures that can cause soil to freeze. For the months of December through March, the mean precipitation in the Region ranges from three inches of water in the northwest to 14.6 inches of water in the south. The mean snowfall in these months ranges

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[1] In accordance with the United States Environmental Protection Agency (2000), Region 5 asked three professional engineers to review a February 2004 draft of this document. The peer review record includes responses to the comments that these individuals provided pursuant to the request.

from 13 inches in the south to 108 inches in the coastal north. The above normals notwithstanding, the only reliable way to predict temperature and precipitation prior to any winter is through statistical analysis of historical data for the location of interest.

To assure effective implementation of the regulations, EPA (2003) has expressed its strong preference that states prohibit the discharge of manure from land application. That is unless the discharge is an agricultural storm water discharge (i.e., a precipitation-related discharge from land where manure was applied in accordance with a nutrient management plan). EPA has also expressed its strong preference for the way in which states should address the timing of land application in their technical standards. With regard to the winter months, EPA strongly prefers that technical standards either prohibit surface application on snow, ice, and frozen soil or include specific protocols that CAFO owners or operators, nutrient management planners, and inspectors will use to conclude whether or not application to a frozen or snow- or ice-covered field or a portion thereof poses a reasonable risk of runoff. Where there is a reasonable risk, EPA strongly prefers that technical standards prohibit application on the field or the pertinent portion thereof during times when the risk exists or may arise.

Technical Guidance

The purpose of this paper is to present technical guidance to which EPA Region 5 will refer as we work together with those states that plan to allow CAFO owners or operators to apply manure on land in the winter where a crop will not be grown in that season or nutrients need not be applied in the winter to grow the crop. For this purpose, Region 5 assumes that the risk of runoff will be minimized if a state requires injection or timely incorporation of manure in the winter, provided that the CAFO owner or operator adheres to the setback requirements in 40 CFR section 412.4(c)(5). Further, we assume that the risk of runoff will be minimized if waters of the United States, sinkholes, open tile line intake structures, and other conduits to waters of the United States are upslope from the land on which manure would be surface applied. Thus, the balance of this technical guidance is intended to provide a basis for the Region to evaluate the adequacy of preliminary technical standards that would allow surface application without timely incorporation where waters of the United States, sinkholes, open tile line intake structures, or other conduits to waters of the United States are downslope from the land on which the manure would be applied[2].

Potential Discharges that are not Precipitation-related

When liquid manure is applied on frozen soil in the absence of snow cover, Region 5 has concluded that the manure will run off and potentially discharge if it is applied in excess of the pertinent rate specified in Table 1a or 1b below[3]. *See* Appendix 2 on page 21 for an example that shows how the Region came to this conclusion. In as much as the discharge of manure is not an agricultural storm water discharge when it is not related to precipitation, technical standards need to prohibit the application of liquid manure on frozen soil, in excess of the rates provided in the following tables, when the soil is not covered with snow.

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[2] For the purpose of this technical guidance, "other conduits to waters of the United States" means any area wherein water is or may be conveyed to waters of the United States via channelized flow.

[3] Region 5 developed the tables for the corn and soybean crops commonly grown in the Region. On request, the Region can supply tables for other land uses and land cover and treatment practices.

Liquid Manure Maximum Rates of Application onto Frozen Soil

Table 1a
Harvested Crops were Row Crops Planted in Straight Rows
Land in Good Hydrologic Condition

Hydrologic Soil Group[4]	Maximum Rate of Application (gallons per acre)
A	3,000
B	1,600
C	1,100
D	1,100

Liquid Manure Maximum Rates of Application onto Frozen Soil

Table 1b
Harvested Crops were Close-seeded Legumes Planted in Straight Rows
Land in Good Hydrologic Condition

Hydrologic Soil Group	Maximum Rate of Application (gallons per acre)
A	4,100
B	2,200
C	1,100
D	1,100

Discharges that are Precipitation-related

When manure is applied on land in the winter, Region 5 assumes that nutrients and manure pollutants will dissolve or become suspended in any precipitation which comes into contact with the manure. This assumption is consistent with the findings reported in Appendix 1 and Table 4. The technical guidance that follows is intended to provide a basis for the Region to evaluate the adequacy of preliminary technical standards as such standards affect the movement of nutrients and manure pollutants in precipitation runoff during the winter or early spring. Six substantive steps are presented below. The first three involve the formulation of state policy for nutrient management. As contemplated in ***Step 1***, the policy should include a standard for the concentration or mass of biochemical oxygen demand in precipitation-related discharges. Nutrients, including ammonia and nitrite, contribute to this demand. The final three involve engineering analysis to determine whether the BOD standard will be met.

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[4] *See* Appendix A in the United States Department of Agriculture, Soil Conservation Service, (1986) for information on the Hydrologic Soil Group within which a given soil is classified. The appendix may be viewed at http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html.

Step 1: In collaboration with the Region, the state establishes a standard for the concentration or mass of BOD that will be permitted in precipitation-related discharges from land on which manure has been surface applied in the winter.

Step 2: ***A.*** The state establishes preliminary technical standards for the setback[5] and the type, form, and maximum quantity of manure that could be surface applied on land in the winter. Standards for the setback should be expressed in terms of distance and slope. The minimum distance is that required under 40 CFR section 412.4(c)(5). As required to use Equations 2 or 3, below, standards for the setback should also be expressed in terms of the land cover and treatment practice and the crop residue rate (in the case of Equation 2) or the Hydrologic Soil Group (in the case of Equation 3). *See* Tables 2 and 3 on pages 10 and 13 for information on various residue rates and land cover and treatment practices.

B. If the standard established in ***Step 1*** is expressed as a mass, the state establishes additional preliminary technical standards for the land cover and treatment practice and Hydrologic Soil Group applicable to land that is upslope from the setback.

Step 3: So the Region can perform the engineering analysis, the state establishes appropriate design conditions for the land use, form of precipitation (rain or ripe snow), depth of precipitation, and the temperature and moisture content of soil. At a minimum, the design condition for the moisture content of soil should be antecedent moisture condition III (i.e., saturated soil) (Wright 2004, Linsley, *et al.*, 1982). States should carefully review climate data to determine whether the design temperature of soil should be 0 °C or less. In no case should the design temperature of soil exceed 3 °C.

Step 4: The Region calculates the percent removal of BOD that will occur in the setback given the design conditions and preliminary technical standards. Calculating the percent removal is a two-step process as shown in ***A.*** and ***B.*** below.

A. Calculate the amount of time it takes water to travel or "concentrate" (T_c) across the setback distance. Two equations are provided below as options for calculating T_c. In general, use Equation 1 (USDA, Natural Resources Conservation Service, 2002a) when the design condition consists of rain on frozen soil or rain on ripe snow or when the preliminary technical standards specify a residue rate equal to or greater than 20 percent. Use Equation 3 (USDA, NRCS, 1993) when the design condition consists of ripe snow, the preliminary technical standards do not specify a residue rate, or the rate is less than 20 percent.

Eq. 1

$$T_c\,(\text{hr}) = T_{t\,(\text{overland})} + T_{t\,(\text{shallow concentrated})}$$

where

$$T_{t\,(\text{overland})} = \frac{0.007 \cdot (N \cdot L)^{0.8}}{(P^{0.5}) \cdot (s^{0.4})} \qquad \text{Eq. 2}$$

[5] The term "setback" is defined in 40 CFR section 412.4 to mean a specified distance from surface waters (i.e., waters of the United States) or potential conduits to surface waters where manure may not be land applied.

N	=	Manning's roughness coefficient for overland flow. *See* Table 2 on page 10 to select a coefficient that is appropriate in light of the preliminary technical standards.
L	=	overland flow portion of the setback distance (maximum of 100 feet) (ft).
P	=	precipitation design depth (in).
s	=	preliminary technical standard for the slope over the distance L (ft/ft).

$T_{t\ (shallow\ concentrated)}$ applies to the shallow concentrated flow portion of the setback distance. In other words, it applies to the portion that is between points (a) and (b) as described below.

Point (a): 100 feet downslope from the furthest downslope point at which manure would be applied under the preliminary technical standards.
Point (b): the nearest waters of the United States, sinkhole, open tile line intake structure, or other conduit to waters of the United States.

$T_{t\ (shallow\ concentrated)}$ is determined by multiplying the above distance times a velocity of runoff that is appropriate in light of the preliminary technical standards. *See* Figure 2 on page 12.

Eq. 3

$$T_c\ (hr) = \frac{5}{3} \cdot \frac{(L^{0.8}) \cdot (S+1)^{0.7}}{1900 \cdot (s^{0.5})}$$

where

L	=	preliminary technical standard for the setback distance (ft).
S	=	potential maximum retention after runoff begins
	=	$\frac{1000}{CN} - 10$
CN	=	runoff curve number. *See* Table 3 on page 13 to select a number that is appropriate in light of the design condition for the land use and the preliminary technical standards.
s	=	preliminary technical standard for the slope over the distance L (percent).

B. Calculate the percent removal of BOD in the setback. The equation for percent removal is as follows (modified from Martel, *et al.*, 1980):

Eq. 4

$$E = (1 - A \cdot e^{-(k_T) \cdot t}) \cdot 100$$

where

E	=	percent removal of BOD.
A	=	nonsettleable fraction of BOD in manure
	=	0.5 to 0.6 for animals other than mature dairy cows (Zhu 2003)
	=	0.9 for mature dairy cows (Wright 2004).
k_T	=	first-order reaction rate constant at the design temperature of soil (T) (°C)
	=	$k \cdot (\theta)^{T-20}$.
θ	=	1.135 (Schroepfer, *et al.,* 1964)
k	=	0.03/min[6].
t	=	detention time
	=	$T_c \cdot 60$.

Step 5: The Region multiplies the percent removal calculated in ***Step 4. B.*** times the initial concentration of BOD in runoff from land where manure has been surface applied (i.e., the concentration prior to treatment of the runoff by land in the setback). If state-specific data are not available, use the values from Table 4 as the basis for assumptions about the initial concentration (*see* page 16). Subtract from the initial concentration the product of the percent removal times the initial concentration. If the standard established in ***Step 1*** is expressed as a mass, proceed to ***Step 6***. If it is expressed as a concentration, compare the final concentration to the standard. If the final concentration is less than or equal to the standard, then the Region will conclude that there is no reasonable risk of runoff. The Region will neither object to nor disapprove the state's preliminary technical standards. However, for the analysis to hold, the technical standards need to require the CAFO owner or operator to verify that conditions in the setback at the beginning of any application are consistent with the values assigned to N or S. In other words, the standards need to prohibit surface application when ice reduces the surface roughness or occupies the surface storage in the setback. If the concentration is greater than the standard established in ***Step 1***, then the Region will conclude that there is a reasonable risk of runoff. Therefore, the final technical standards need to prohibit surface application of manure in the winter (or on frozen or snow-covered soil) or the state needs to otherwise strengthen the preliminary technical standards so there is no reasonable risk of runoff.

Step 6: If the standard is expressed as a mass, the Region calculates the mass of BOD that will run off the land given the design conditions for the land use, depth of precipitation, soil temperature, and soil moisture content as well as the preliminary technical standards for the Hydrologic Soil Group, land cover and treatment practice, and the type and maximum quantity of liquid manure. Calculating the mass is a three-step process as shown below.

A. Use the following equation (USDA, NRCS, 1993) to calculate the inches of runoff.

---

[6] The k value of 0.03 per minute is as reported by Martel, *et al.*, for treatment of municipal wastewater by the overland flow process. The Region assumes that Martel, *et al.*, reported the constant at 20 °C consistent with standard engineering practice.

Eq. 5

$$Q = \frac{(P - 0.2 \cdot S)^2}{(P + 0.8 \cdot S)}$$

where

Q = runoff (in).

P = precipitation design depth plus the depth of water that could be applied in the winter as liquid manure given the preliminary technical standards (in).

S is as defined for Equation 3 except that, if the design temperature of soil is 0 °C or less, substitute S_f for S where $S_f = (0.1 \cdot S)$ (Mitchell, *et al.*, (1997)).

B. Use the following equation to convert the runoff from inches to a volume per acre.

Eq. 6

$$Q\ (gal/ac) = Q(in) \cdot ft/12\ in \cdot 43{,}560\ ft^2/ac \cdot 7.48\ gal/ft^3$$

C. Calculate the mass of BOD in runoff by multiplying the volume of runoff times the final concentration of BOD calculated in ***Step 5.*** The equation is as follows:

Eq. 7

$$BOD\ (lb/ac) = BOD\ (mg/L) \cdot Q\ (gal/ac) \cdot 3.7854\ L/gal \cdot g/1000mg \cdot 0.0022\ lb/g$$

Compare the mass with the standard established in ***Step 1***. If the mass is less than or equal to the standard, then the Region will conclude that there is no reasonable risk of runoff. The Region will neither object to nor disapprove the preliminary technical standards. However, for the analysis to hold, the technical standards need to require the CAFO owner or operator to verify that conditions in the setback at the beginning of any application are consistent with the values assigned to N or S. In other words, the standards need to prohibit surface application when ice reduces the surface roughness or occupies the surface storage in the setback. If the mass is greater than the standard established in ***Step 1***, then the Region will conclude that there is a reasonable risk of runoff. Therefore, the final technical standards need to prohibit surface application of manure in the winter (or on frozen or snow-covered soil) or the state needs to otherwise strengthen the preliminary technical standards so there is no reasonable risk of runoff.

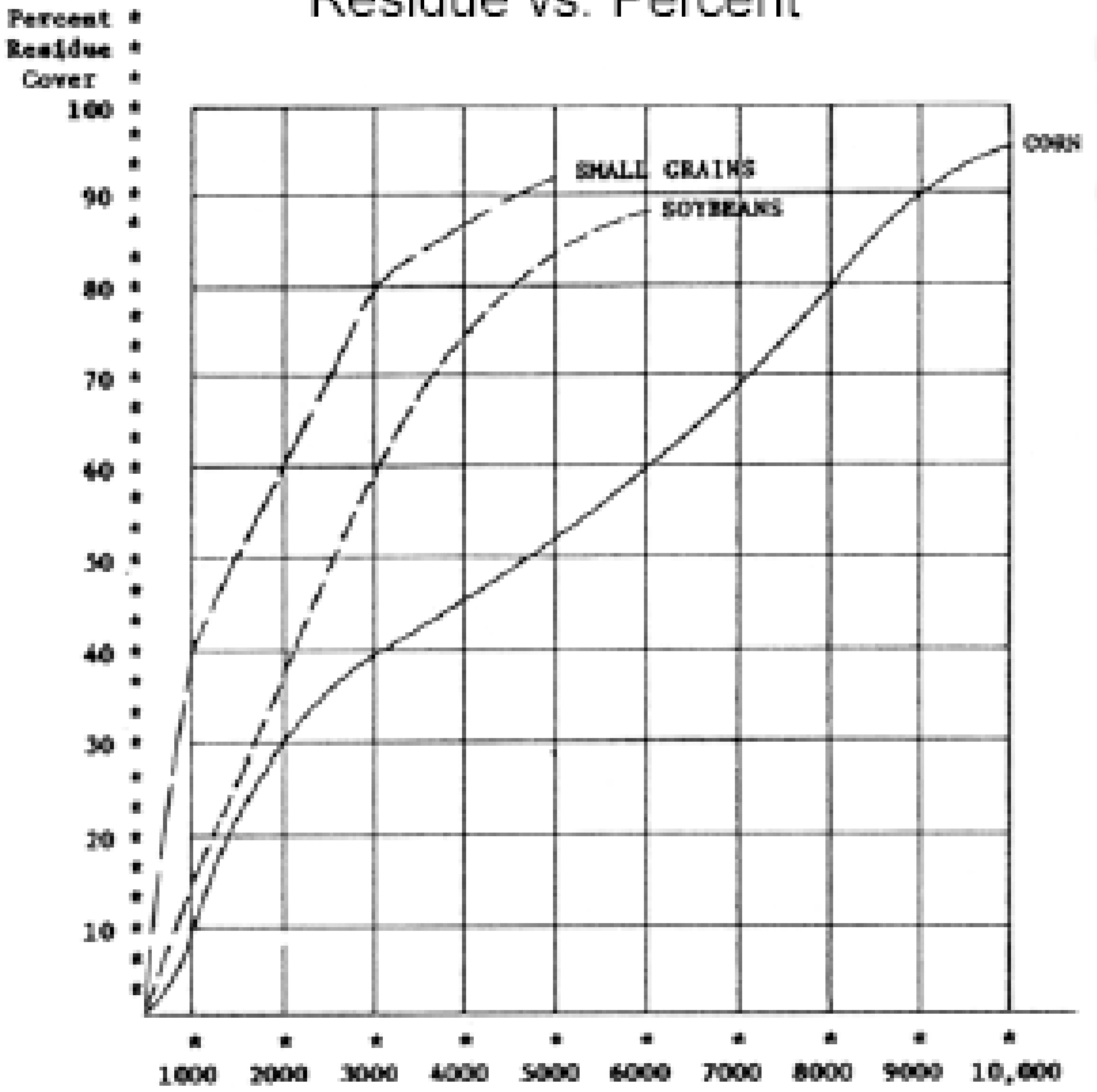
Table 2

Recommended Manning's Roughness Coefficients for Overland Flow
Engman (1986)

Cover or treatment	**Residue rate** (ton/acre)[7]	**Recommended coefficient**	**Range**
Bare clay-loam (eroded)		0.02	0.012 to 0.033
Fallow - no residue		0.05	0.006 to 0.16
Chisel plow	< 0.25	0.07	0.006 to 0.17
	0.25 to 1	0.18	0.07 to 0.34
	1 to 3	0.3	0.19 to 0.47
	> 3	0.4	0.34 to 0.46
Disk/harrow	< 0.25	0.08	0.008 to 0.41
	0.25 to 1	0.16	0.1 to 0.25
	1 to 3	0.25	0.14 to 0.53
	> 3	0.3	--
No till	< 0.25	0.04	0.03 to 0.07
	0.25 to 1	0.07	0.01 to 0.13
	1 to 3	0.3	0.16 to 0.47
Moldboard plow (fall)		0.06	0.02 to 0.1
Coulter		0.1	0.05 to 0.13
Range (natural)		0.13	0.02 to 0.32
Range (clipped)		0.1	0.02 to 0.24
Short grass prairie		0.15	0.1 to 0.2
Dense grass		0.24	0.17 to 0.3

[7] *See* Figure 1 to convert residue cover from a percent to a mass.

Figure 1 – Pounds of Residue vs. Percent



USDA, NRCS, (2002b).

Figure 2

Average Velocity of Shallow Concentrated Flow
USDA, NRCS, (1993)

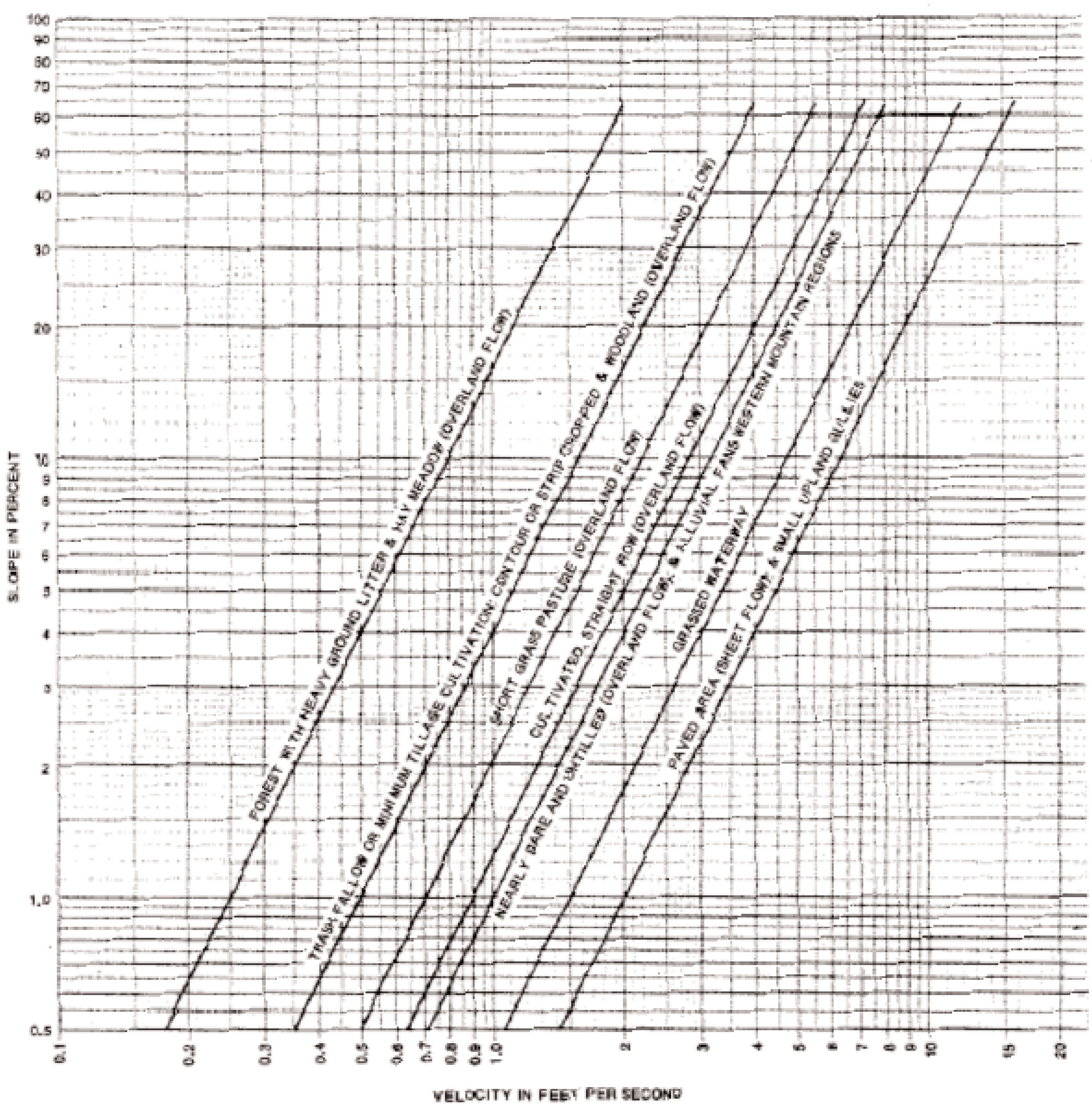


Table 3

Runoff Curve Numbers for Hydrologic Soil-Cover Complexes[8]
USDA, NRCS, (1993), USDA, SCS, (1986)

Land use	**Treatment or practice**	**Hydrologic condition**[9]	**Hydrologic Soil Group**			
			A	**B**	**C**	**D**
Fallow	Bare soil		89	94	97	98
	Crop residue cover	Poor	89	94	96	98
	“	Good	88	93	95	96
Row crops	Straight row	Poor	86	92	95	97
	“	Good	83	90	94	96
	Straight row and crop residue cover	Poor	86	91	95	96
	“	Good	81	88	92	94
	Contoured	Poor	85	91	93	95
	“	Good	82	88	92	94
	Contoured and crop residue	Poor	84	90	93	95
	“	Good	81	88	92	94
	Contoured and terraced	Poor	82	88	91	92
	“	Good	79	86	90	92

[8] The runoff curve numbers in Table 3 apply to saturated soil conditions (i.e., antecedent moisture condition III). *See* Appendix 3 on page 22 for runoff curve numbers applicable to average soil moisture conditions.

[9] According to USDA, SCS, (1986), hydrologic condition is based on a combination of factors, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percent of residue cover on the land surface (good ≥ 20 percent), and (e) degree of surface roughness.

Land use	Treatment or practice	Hydrologic condition	Hydrologic Soil Group			
			A	B	C	D
	Contoured, terraced, and crop residue	Poor	82	87	91	92
	"	Good	78	85	89	91
Small grain	Straight row	Poor	82	89	93	95
	Contoured	Poor	80	88	92	94
	"	Good	78	87	92	93
	Contoured and crop residue	Poor	79	87	92	93
	"	Good	78	86	91	93
	Contoured and terraced	Poor	78	86	91	92
	"	Good	77	85	90	92
	Contoured, terraced, and crop residue	Poor	78	86	90	92
	"	Good	76	84	89	91
Close-seeded legumes[10] or rotation meadow	Straight row	Poor	82	89	94	96
	"	Good	76	86	92	94
	Contoured	Poor	81	88	93	94
	"	Good	74	84	90	93
Close-seeded legumes[11] or rotation meadow	Contoured and terraced	Poor	80	87	91	93

[10] Close-drilled or broadcast.

[11] Close-drilled or broadcast.

Land use	Treatment or practice	Hydrologic condition	Hydrologic Soil Group			
			A	B	C	D
	"	Good	70	83	89	91
Pasture or range		Poor	84	91	94	96
		Fair	69	84	91	93
		Good	59	78	88	91
	Contoured	Poor	67	83	92	95
	"	Fair	43	77	88	93
	"	Good	13	55	85	91
Meadow		Good	50	76	86	90

Table 4

Assumed Initial Concentration of BOD in Runoff from Land on which Manure or Process Wastewater has been Surface Applied

Type of Material	Initial Total BOD in Runoff (mg/L)
Broiler manure[12]	708
Cattle (other than mature dairy cow) manure	Reserved
Cattle open lot process wastewater	Reserved
Egg wash process wastewater	Reserved
Feed storage process wastewater	Reserved
Layer manure[13]	809
Mature dairy cow manure[14]	924
Swine manure[15]	204
Turkey manure	Reserved

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[12] Daniel, *et al.*, (1995).

[13] Ibid.

[14] Thompson, *et al.*, (1979)

[15] Daniel, *et al.*, (1995).

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Appendix L-1

The following is an excerpt from EPA (2002):

> [C]onsiderable research has demonstrated that runoff from manure application on frozen or snow-covered ground has a high risk of water quality impact. Extremely high concentrations of nitrogen and phosphorus in runoff have been reported from plot studies of winter-applied manure: 23.5 to 1,086 milligrams (mg) of total kjeldahl nitrogen (TKN) per liter (L) and 1.6 to 15.4 mg/L of phosphorus (P) (Thompson, *et al.* 1979; Melvin and Lorimor 1996). In two Vermont field studies, Clausen (1990, 1991) reported 165 to 224 percent increases in total P concentrations, 246 to 1,480 percent increases in soluble P concentrations, 114 percent increases in TKN concentrations, and up to 576 percent increases in ammonia-nitrogen (NH_3-N) following winter application of dairy manure. Mass losses of up to 22 percent of applied nitrogen and up to 27 percent of applied P from winter-applied manure have been reported (Midgeley and Dunklee 1945; Hensler, *et al.*, 1970; Phillips, *et al.*, 1975; Converse, *et al.*, 1976; Klausner, *et al.,* 1976; Young and Mutchler 1976; Clausen 1990 and 1991; Melvin and Lorimor 1996). Much of this loss can occur in a single storm event (Klausner, *et al.,* 1976). Such losses may represent a significant portion of annual crop needs.
>
> On a watershed basis, runoff from winter-applied manure can be an important source of annual nutrient loadings to water bodies. In a Wisconsin lake, 25 percent of annual P load from animal waste sources was estimated to arise from winter spreading (Moore and Madison 1985). In New York, snowmelt runoff from winter-manured cropland contributed more P to Cannonsville Reservoir than did runoff from poorly managed barnyards (Brown, *et al.,* 1989). Clausen and Meals (1989) estimated that 40 percent of Vermont streams and lakes would experience significant water quality impairments from the addition of just two winter-spread fields in their watersheds.
>
> Winter application of manure can increase microorganism losses in runoff from agricultural land compared to applications in other seasons (Reddy, *et al.*, 1981). Cool temperatures enhance survival of fecal bacteria (Reddy *et al.*, 1981; Kibby, *et al.*, 1978). Although some researchers have reported that freezing conditions are lethal to fecal bacteria (Kibby, *et al.,* 1978; Stoddard, *et al.*, 1998), research results are conflicting. Kudva, *et al.*, (1998) found that *Escherichia coli* can survive more than 100 days in manure frozen at minus 20 degrees Celsius. Vansteelant (2000) observed that freeze/thaw of soil/slurry mix only reduced *E. coli* levels by about 90 percent. Studies have found that winter spreading of manure does not guarantee die-off of *Cryptosporidium* oocysts (Carrington and Ransome 1994; Fayer and Nerad 1996). Although several studies have reported little water quality impact from winter-spread manure (Klausner 1976; Young and Mutchler 1976; Young and Holt 1977), such findings typically result from fortuitous circumstances of weather, soil properties, and timing/position of manure in the snowpack. The spatial and temporal variability and unpredictability of such factors makes the possibility of ideal conditions both unlikely and impossible to predict.

Appendix L-2

Example Derivation of the Maximum Rates for Liquid Manure Application on Frozen Soil

Givens

According to USDA, NRCS, (1993), the following are givens:

Potential maximum retention after runoff begins (S) = $\frac{1000}{CN} - 10$

Runoff curve number (CN) = $\frac{1000}{S + 10}$

According to Mitchell, *et al.,* (1997), the following is a given for frozen soil:

$S_f = 0.1 \cdot S$

For CN in the range from zero to 100, Table 10.1 in USDA, NRCS, (1993), identifies the minimum depth of precipitation (P) at which the runoff curve begins under dry, average, and saturated antecedent soil moisture conditions. For example, for a CN of 91 and average antecedent soil moisture, the runoff curve begins when P equals 0.2 inches.

Example

Hydrologic Soil Group A.
Harvested crop was corn planted in straight rows.
The land is in good hydrologic condition.
The antecedent soil moisture is average.

$S_f = (1000/64 - 10) \cdot 0.1 = 0.56$

$CN_f = 1000/(0.56 + 10) = 94.7 \simeq 95$

According to Table 10.1 in USDA, NRCS (1993), for a CN of 95, 0.11 inches is the minimum depth of precipitation (or other liquid) at which the runoff curve begins. Converting this depth to a volume per acre,

$Q\ (gal/ac) = 0.11\ in \cdot ft/12\ in \cdot 43{,}560\ ft^2/ac \cdot 7.48\ gal/ft^3$

results in 2,987 gallons per acre as the maximum quantity of liquid that can be applied on frozen soils in Hydrologic Soil Group A while precluding runoff.

Appendix L-3

Runoff Curve Numbers for Antecedent Moisture Condition II

If the Curve Number for AMC III is ...	then the Curve Number for AMC II is ...
100	99
99	96
98	93
97	91
96	89
95	87
94	85
93	83
92	81
91	79
90	78
89	76
88	74
87	73
86	71
85	70
84	68
83	67
82	65
81	64
80	63
79	62

If the Curve Number for AMC III is ...	then the Curve Number for AMC II is ...
78	60
77	59
76	58
75	57
74	55
73	54
72	53
71	52
70	50
69	49
68	48
67	47
66	46
65	45
64	44
63	43
62	42
61	41

APPENDIX M - MINIMUM DEPTH OF RAIN AT WHICH RUNOFF BEGINS

This appendix provides a methodology for estimating the minimum depth of precipitation required to produce runoff for a given field with a given runoff curve number.

Step 1: Estimate the runoff curve for the field or land area of concern. Table 3 in Appendix L provides curve numbers for various combinations of land uses (e.g., row crops), cover treatment or practices (e.g., contoured), and hydrologic conditions (e.g., poor). The runoff curve numbers in this table represent Antecedent Moisture Condition III (e.g., saturated soils). To identify corresponding runoff curve numbers for Antecedent Moisture Condition II (i.e., average conditions) use either Appendix L-3 above or Tables 2-2b and 2-2c in Urban Hydrology for Small Watersheds, USDA-NRCS, 1986 (see Appendix M-2). To predict the possibility of runoff where rainfall is forecast in a season other than winter, it may be reasonable to use runoff curves for Antecedent Moisture Condition II.

Step 2: Using Table 10.1 on page 10.7 of the USDA-NRCS National Engineering Handbook Part 630, Hydrology (see Appendix M-1); select the curve number (CN) for the field being investigated.

Step 3: For the selected curve number in Table 10.1, identify the minimum depth of precipitation in inches required to produce runoff for a given runoff curve number (Column 5, designated with the column header of Curve* starts where P =).

Appendix M-1
National Engineering Handbook Table 10.1
Curve numbers (CN) and Constants for the Case Ia = 0.2 S

Table 10.1. Curve numbers (CN) and constants for the case $I_a = 0.2$ S

1	2	3	4	5	1	2	3	4	5
CN for condition II	CN for conditions I	III	S values*	Curve* starts where P =	CN for condition II	CN for conditions I	III	S values*	Curve* starts where P =
			(inches)	(inches)				(inches)	(inches)
100	100	100	0	0	60	40	78	6.67	1.33
99	97	100	.101	.02	59	39	77	6.95	1.39
98	94	99	.204	.04	58	38	76	7.24	1.45
97	91	99	.309	.06	57	37	75	7.54	1.51
96	89	99	.417	.08	56	36	75	7.86	1.57
95	87	98	.526	.11	55	35	74	8.18	1.64
94	85	98	.638	.13	54	34	73	8.52	1.70
93	83	98	.753	.15	53	33	72	8.87	1.77
92	81	97	.870	.17	52	32	71	9.23	1.85
91	80	97	.989	.20	51	31	70	9.61	1.92
90	78	96	1.11	.22	50	31	70	10.0	2.00
89	76	96	1.24	.25	49	30	69	10.4	2.08
88	75	95	1.36	.27	48	29	68	10.8	2.16
87	73	95	1.49	.30	47	28	67	11.3	2.26
86	72	94	1.63	.33	46	27	66	11.7	2.34
85	70	94	1.76	.35	45	26	65	12.2	2.44
84	68	93	1.90	.38	44	25	64	12.7	2.54
83	67	93	2.05	.41	43	25	63	13.2	2.64
82	66	92	2.20	.44	42	24	62	13.8	2.76
81	64	92	2.34	.47	41	23	61	14.4	2.88
80	63	91	2.50	.50	40	22	60	15.0	3.00
79	62	91	2.66	.53	39	21	59	15.6	3.12
78	60	90	2.82	.56	38	21	58	16.3	3.26
77	59	89	2.99	.60	37	20	57	17.0	3.40
76	58	89	3.16	.63	36	19	56	17.8	3.56
75	57	88	3.33	.67	35	18	55	18.6	3.72
74	55	88	3.51	.70	34	18	54	19.4	3.88
73	54	87	3.70	.74	33	17	53	20.3	4.06
72	53	86	3.89	.78	32	16	52	21.2	4.24
71	52	86	4.08	.82	31	16	51	22.2	4.44
70	51	85	4.28	.86	30	15	50	23.3	4.66
69	50	84	4.49	.90					
68	48	84	4.70	.94	25	12	43	30.0	6.00
67	47	83	4.92	.98	20	9	37	40.0	8.00
66	46	82	5.15	1.03	15	6	30	56.7	11.34
65	45	82	5.38	1.08	10	4	22	90.0	18.00
64	44	81	5.62	1.12	5	2	13	190.0	38.00
63	43	80	5.87	1.17	0	0	0	infinity	infinity
62	42	79	6.13	1.23					
61	41	78	6.39	1.28					

*For CN in column 1.

Appendix M-2
USDA Urban Hydrology for Small Watersheds (TR-55)

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description: Cover type and hydrologic condition	Average percent impervious area 2/	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) 4/		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) 5/		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands 1/

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment 2/	Hydrologic condition 3/	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Appendix M-3

Instructions for
Determining Precipitation Forecasts for CAFO Permits
using the
National Weather Service website

WARNING: Do not be intimidated. This is much easier then it may seem at first. Once you learn how to do this and save the results in your Favorites you can check both forecasts in less then a minute (or up to a few minutes depending on your internet connection speed). In fact, you may find these forecast models useful in planning other areas of work on your farm.

Start at this website: http://www.nws.noaa.gov/mdl/synop/products.shtml. Once you are there you may wish to save it in your Favorites. If the website has changed or the required forecast models are not longer available, please contact the Michigan Department of Environmental Quality Office listed on your Certificate of coverage or on the cover page of your permit

1. Click on "Forecast Graphics" in the "GFS MOS (MAV)" box (near the center of the page).

2. In the column on the left side, in the drop down box under "Precipitation", click on "24H Prob. >= 0.50 in.". Note: if it has been determined that a smaller precipitation event is capable of producing runoff or erosion then use a smaller precipitation probability such as "24H Prob. >= 0.25 in.".

3. This will bring up a map of the U.S. showing precipitation probabilities as colored bands or areas for the upcoming 24 hour period. Precision is not ideal because it covers all of the U.S. but estimate the color for the proposed land application area. If the precipitation probability is 70% or greater (blue shades) then you may not land apply. You can save the map in your favorites.

4. Underneath the map are day & time boxes such as "Tuesday" and "00" and "12". That would be Tuesday midnight and noon, GMT (Greenwich Mean Time) which is 5 hours ahead of EST (Eastern Standard Time) and 4 hours ahead of EDT(Eastern Daylight Time). So "Tuesday 00" would be 7 p.m. EST or 8 p.m. EDT Monday. The map forecast is for the 24 hour period ending at the highlighted time. The first box, which will be highlighted when you bring up the map, will give the map for the upcoming 24 hour period. You can click on subsequent time periods to see future forecasts. You should always check the immediate upcoming 24 hour forecast just prior to a planned land application event.

After you have finished checking the maps use your back button or go to your Favorites to return to the above website.

1. Click on "Text Message By Station List" in the "GFS MOS (MEX)" box (toward the right side on the page).

2. In the list of states on the left side click on "Michigan".

3. In the list that comes up on the right side click in the box for the station closest to the land application location. You may need to select 2 or 3 stations if none are close to the land application area. If selecting more then one station, note the 4-letter station designation after each station name so you know which chart is for which station.

4. Once you have selected the station(s) scroll to the bottom of the Michigan station list and click on "Go to the bottom to submit now". Then click on the "Submit Query" box.

5. You will now have a very confusing chart for each selected station (you can save this page in your Favorites). Look down the left hand column for "Q24" and read across the first number. It will be one digit from 0 to 6. This is the only number you need to be concerned with. This number is the quantity precipitation forecast for the upcoming 24 to 48 hour period. 0 = no precipitation, 1 = 0.01" to 0.09", 2 = 0.1" to 0.24", 3 = 0.25" to 0.49", 4 = 0.5" to 0.99", 5 = 1.0" to 1.99" and 6 = > 2.0". If it is 4 or greater you may not land apply. Note: if it has been determined that a smaller precipitation event is capable of producing runoff or erosion then use a smaller precipitation quantity forecast number. For example, if 0.35" of precipitation in 24 hours on a particular field will produce runoff or erosion then you may not land apply if the number is 3 or greater.

6. You may need to check the charts 2 or 3 times in advance of a planned land application event to determine the precipitation amount forecasted for the land application time frame.

In the event that you are immensely curious as to what all the rest of the data on these charts mean, then go back to the website at the top on these instructions and in the left hand column click on "GFS Description" to get to an explanation page.

Once you have saved the map and charts in your Favorites, you can click on those links and get to the current map or chart(s) with just one click!

APPENDIX N - RECOMMENDED BEST MANAGEMENT PRACTICES (BMPS) AND CONSERVATION PRACTICE STANDARDS

There are several Best Management Practices (BMPs) and conservation practices to consider when planning and implementing a Nutrient Management Plan (NMP). This appendix contains some of USDA's published practices, though many other practices exist. The practices you see here represent those that EPA believes may be the most helpful when planning your NMP. Consult your state or local Cooperative Extension Office for more information and other standards and practices.

Description

The Natural Resources Conservation Service (NRCS) is a division of USDA that provides leadership in a partnership effort to help people conserve, improve, and sustain our natural resources and the environment. NRCS relies on many partners to help set conservation goals, work with people on the land, and provide assistance. Its partners include conservation districts, state and federal agencies, NRCS Earth Team volunteers, agricultural and environmental groups, and professional societies.

NRCS has published the National Handbook of Conservation Practices (NHCP), which includes conservation practice standards guidance for applying technology on the land, and sets the minimum level for acceptable application of the technology. The most commonly considered conservation practice standards that may be used are shown in the table below:

Practice	Practice
Composting Facility (a)	Pond Sealing or Lining - Flexible Membranes (a)
Conservation Crop Rotation (a)	Pond Sealing or Lining - Bentonite Sealant (a)
Contour Buffer Strips (a)	Residue Management, no-till and Strip Till
Cover and Green Manure Crop	Residue Management, Mulch Till
Cross Wind Trap Strips	Roof Runoff Management
Diversions	Spring Development
Fences	Strip cropping, Contour
Filter Strips (a)	Terraces
Grade Stabilization Structure	Trough or Tank
Grassed Waterways	Use Exclusion
Irrigation Water Management	Waste Management Systems (a)
Nutrient Management (a)	Waste Storage Facility (a)
Pest Management	Waste Treatment Lagoon (a)
Pipelines	Waste Utilization (a)

National standards for each practice are available at the NRCS web site at **http://www.ncg.nrcs.usda.gov/nhcp_2.html**. State conservationists determine the national standards to apply on a state-wide level, and add detail to effectively implement the standards on a local level, including more restrictive levels, if warranted. Local standards cannot be less restrictive than the national standards.

References

Natural Resources Conservation Service, Department of Agriculture. Notice of Technical Guidance for Developing Comprehensive Nutrient Management Plans (CNMPs).

Who to Contact for More Information

Your Local Cooperative Cooperative Extension Office
Your Local Land Grant University
National Water Management Center/Natural Resources Conservation Service (USDA)

APPENDIX O - EXAMPLE TECHNICAL STANDARD

EXAMPLE EPA NUTRIENT MANAGEMENT TECHNICAL STANDARD

I. Authority

- 40 CFR 122.42
- 40 CFR 123.36
- 40 CFR 412.4
- 40 CFR 412.37

II. Applicability

This technical standard applies to all land under the control of a CAFO owner or operator, whether it is owned, rented, leased, or under an access agreement, to which manure, litter, process wastewater or sludge from the production area is or may be applied, in States, Indian Country, and other Territories and Jurisdictions where US EPA has NPDES permit authority.

III. Definition

Nutrient management is a planned process to protect water quality by managing the amount, source, placement, form, timing and method of application of agricultural nutrients and soil amendments utilized for the production of crop, forage, fiber, and forest products. It is supplying essential nutrients in adequate amounts to balance and maintain the soil for healthy biology and quality plants while avoiding conditions inimical to the ecosystem.

IV. Purposes

A. Minimize pollution of waters of the United States from agricultural nutrient sources.

B. Budget and supply nutrients for plant production

C. Properly use manure, litter, process wastewater, and/or other organic by-products as a plant nutrient source.

D. Maintain or improve the physical, chemical, and biological condition of the soil.

V. Criteria

A. Nutrient Management Plans Shall Meet the Following General Criteria

A nutrient management plan (NMP) is a site specific, documented, management tool, prepared for reference and used by the producer or landowner, recording how nutrients are and will be used to achieve plant production and water quality protection.

1. NMPs shall comply with all applicable federal, State, and local laws and regulations. The CAFO must reviewed the NMP annually.

2. Plans for nutrient management shall be in accordance with the requirements of 40 CFR 122.42, 412.4 and 412.37. Sources of information, among other things, to assist in the development of the plan can be found in the policy requirements of the NRCS General Manual Title 450, Part 401.03 (Technical Guides, Policy and

Responsibilities) and Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy); technical requirements of the NRCS Field Office Technical Guide (FOTG); procedures contained in the National Planning Procedures Handbook (NPPH), the NRCS National Agronomy Manual (NAM) Section 503 and NRCS Conservation Practice Standard Nutrient Management (590).

3. Plans for nutrient management that are elements of a more comprehensive conservation plan shall recognize other requirements of the conservation plan and be compatible with its other requirements.

4. The use of certified specialists in developing nutrient management plans is not required, but EPA does encourage CAFOs to make use of certified planners with the expertise to develop, or review and modify nutrient management plans. A certified planner is defined as someone who has been certified to prepare CNMPs by USDA or a USDA sanctioned organization.

5. Plans developed for nutrient management that include the use of manure or other organic by-products will identify the size of the land base needed to enable plan implementation based on phosphorus, even when initial implementation will be based on nitrogen, unless other provisions that do not involve land application are made for utilizing the manure.

6. A nutrient budget for nitrogen, phosphorus, and potassium must be developed that considers all potential sources of nutrients including, but not limited to animal manure and organic by-products, wastewater, biosolids, commercial fertilizer, crop residues, legumes credits, and irrigation water.

THE FOLLOWING ARE KEY ELEMENTS IN THE DEVELOPMENT OF AN NMP

B. Soil Sampling and Laboratory Analysis (Testing)

1. CAFOs in nutrient **non-impaired** watersheds shall soil sample every 5 years at a minimum. CAFOs in watersheds listed on the CWA Section 303(d) list as nutrient **impaired** and CAFOs having a field(s) with Phosphorus Index Site Vulnerability Rating(s) of **high** or **very high** shall sample annually.

2. Soil samples shall be collected and prepared according to the Land Grant University guidance or standard industry practice.

3. Soil samples shall be analyzed according to accepted industry practice or Land Grant University guidance. Soil test analyses shall be performed by laboratories that are accepted in one or more of the following programs.

   a. State Certified Programs

   b. The North American Proficiency Testing Program (Soil Science Society of America), or

   c. Laboratories whose tests are accepted by Land Grant University in the State in which the tests will be used.

4. Soil testing shall include analysis for any nutrients and soil components for which specific information is needed to develop the nutrient plan and monitor or amend

the annual nutrient budget. Analyses are recommended for pH, electrical conductivity (EC), soil organic matter, nitrogen, phosphorus and potassium.

5. The laboratory analysis for phosphorus shall be performed using the method recommended by the Land Grant University or by the following method: where the soil pH (using water pH test) is 7.5 or greater, an Olsen P-test will be done; where the soil pH is less than 7.5, the Mehlich 3 or Bray P-test will be done.

C. Plant Tissue Sampling

1. Tissue sampling and testing, where used, shall be collected, prepared, and analyzed according to accepted industry practice or Land Grant University guidance where it should be used.

D. Manure and Wastewater Sampling (See Appendix C for waste sampling procedures)

1. Manure and wastewater shall be analyzed a minimum of once annually for nitrogen and phosphorus content. The results of this analysis is to be used in determining application rates of manure, litter and wastewater.

2. Manure and wastewater samples shall be collected, prepared, and analyzed according to accepted industry practice or Land Grant University guidance.

E. Field Risk Assessment

1. When animal manures or other organic by-products are land applied, a field-specific assessment of the potential for phosphorus transport from the field shall be completed. This assessment may be done using the Phosphorus Index or other recognized assessment tool adopted by the permitting authority. In such cases, plans shall include:

a. A record of the assessment rating for each field or sub-field, and

b. Information about conservation practices and management activities that can reduce the potential for phosphorus movement from the site.

2. Erosion, runoff, and water management controls shall be installed, as needed, on fields that receive nutrients. Practices to control erosion should be less than or equal to “T”, as identified by the Revised Universal Soil Loss Equation (RUSLE).

F. Nutrient Application Rates

1. **Nitrogen Application** - The application rate for nitrogen shall be based on the utilization of crops at the recommended agronomic rates. When the plan is being implemented on a phosphorus standard, manure or other organic by-products shall be applied at rates, consistent with the phosphorus standard. In such situations, an additional nitrogen application, from non-organic sources, may be required to supply the recommended amounts of nitrogen. In no case shall manure or other organic by-products be applied above the nitrogen rate.

Manure or other organic by-products may be applied on legumes at rates equal to the estimated removal of nitrogen in harvested plant biomass.

2. **Phosphorus Application** - When manure or other organic by-products are used, the planned rates of phosphorus application shall be consistent with one of the following options:

   a. **Phosphorus Index (PI) Rating**
   Nitrogen or multi-year phosphorus based manure application on Low or Medium Risk sites, one-year phosphorus based manure application on High Risk sites and no manure application on Very High Risk Sites.

   b. **Soil Phosphorus Threshold Values**
   Nitrogen or multi-year phosphorus based manure application on sites on which soil test levels are below 0.75 times the threshold level, one-year phosphorus based manure application on sites on which soil test levels are more than 0.75 but less than 1.5 times the threshold level, and no manure application on sites on which soil test levels are more than 1.5 times the threshold level.*

   c. **Soil Test**
   Nitrogen or multi-year phosphorus based manure application on sites where there is a soil test recommendation to supply phosphorus. One-year phosphorus based manure application on sites where the soil test level is greater than 75 but less than 150 ppm Bray P1. No manure application on sites where the soil test level is equal to or greater than 150 ppm Bray P1.

   *Acceptable phosphorus based manure application rates shall be determined as a function of soil test recommendations or estimated phosphorus removal in harvested plant biomass. Guidance for developing these acceptable rates is found in the NRCS General Manual, Title 190, Part 402 (Ecological Sciences, Nutrient Management, Policy), and the National Agronomy Manual, Section 503.

3. Planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on soil test results, nutrient credits, waste analysis, crop need and sequence, seasonal and climatic conditions, and use and timing of irrigation water.

4. Realistic yield goals shall be established based on soil productivity information, historical yield data, climatic conditions, level of management and/or local research on similar soil, cropping systems, and soil and manure/organic by-products tests. For new crop or varieties, industry yield recommendations may be used until documented yield information is available.

5. Plans for nutrient management shall specify the form, source, amount, timing, and method of application of nutrients on each field to achieve realistic production goals, while minimizing nitrogen and/or phosphorus movement to surface and/or ground waters.

6. When actual crop yields exceed or fail to attain expected goals, the nutrient application rates for the succeeding crop must be adjusted to reflect that difference.

7. Nutrient values of manure, litter, process wastewater, sludge, and organic by-products shall be determined prior to land application based on laboratory

analysis. "Book values" shall not be used except for planning of first year application(s) during initial start-up of the facility. Acceptable book values are those values recognized by ASAE, the NRCS, and/or the Land Grant University that accurately estimate the nutrient content of the material.

8. Nutrient application rates shall not attempt to approach a site's maximum ability to contain one or more nutrients as determined by the risk assessment methods in V.F.1.and 2. Excess applications or applications that cause soil imbalances should be avoided. Excess manure nutrients generated by the CAFO must be handled by export to a good steward of the manure, or the development of alternative uses.

9. Nutrients shall be applied in such a manner as not to degrade the soil's structure, chemical properties, or biological condition.

10. The planned rates of nutrient application, as documented in the nutrient budget, shall be determined based on the following guidance:

    a. *Nitrogen Application* - Planned nitrogen application rates shall match the recommended rates as closely as possible. When manure or other organic by-products are a source of nutrients, additional nitrogen application, from non-organic sources, may be required to supply the recommended amounts of nitrogen. Split applications of nitrogen should be practiced to provide nutrients at the time of maximum crop utilization.

    b. *Phosphorus Application* - Planned phosphorus application rates shall match the recommended rates as closely as possible.

11. Consider the use of variable-rate technology for management of supplemental nitrogen application to account for within-field spatial and temporal variability.

12. **Multiple-year phosphorus applications ("phosphorus banking")** - A single, multiple-year application of phosphorus applied as manure, litter, process wastewater, sludge, or other organic by-product may be applied to a field that does not have a high potential for nutrient movement as determined by one of the risk assessment methods in V.F.1. and 2. above. In a nutrient **non-impaired** watershed, this application shall not exceed the one year nitrogen application rate and shall not exceed three (3) times the one year phosphorus application rate. Following a multiple-year application in a nutrient non-impaired watershed, no application may be made until the applied phosphorus has been removed from the field via harvest or crop removal. In a nutrient **impaired** watershed, this application shall not exceed the nitrogen application rate and shall not exceed two (2) times the one year phosphorus application rate. Following a multiple-year application in a nutrient impaired watershed, no application may be made until the applied phosphorus has been removed from the field via harvest or crop removal. The multiple-year rates may be applied only if erosion and runoff control practices and buffers are installed to minimize risk of nutrient movement.

G. Nutrient Application Timing

1. Manure, litter, or process wastewater shall not be surface applied when the National Weather Service predicts a 50 percent or more probability of rain in excess of the amount that is reasonably likely to generated runoff, as provided below, within 24 hours of the end of an intended application.

Minimum Quantity of Rainfall Required to Produce Runoff

Hydrologic Soil Group	Quantity of Rainfall (inches)
A	1.0
B	0.5
C	0.25
D	0.25

See Appendix A in *Urban Hydrology for Small Watersheds* (USDA-SCS 1986) for information on the Hydrologic Soil Group within which a given soil is classified. The appendix may be viewed at http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html. The National Weather Service forecast may be viewed at http://www.nws.noaa.gov/mdl/forecast/graphics/MAV/index.html. At that address, select the precipitation forecast product that is appropriate given the Hydrologic Soil Group that represents the predominant soil type in the field where manure, litter, or process wastewater would be applied. For Hydrologic Soil Group B soils, this would be the forecast product labeled, "24H Prob.>=0.5in.," for example. If the map that appears after selecting this product does not allow one to determine whether there is a 50 percent or more probability of the specified quantity of rain near the place where the field is located, then select the following National Weather Service address: http://www.nws.noaa.gov/mdl/synop/products/bullform.mex.htm. At that address, first select the state in which the field is located and then select the weather station closest to the field. Then press "Submit Query" at the bottom of the page. A table will appear after submitting the query. Locate the "Q24" entry in the first column and then locate the first number to the right of "Q24". This number will be in the range from 0 to 6. These values correspond to the following amounts of precipitation: 0 = no precipitation, 1 = 0.01 to 0.09", 2 = 0.1 to 0.24", 3 = 0.25 to 0.49", 4 = 0.5 to 0.99", 5 = 1 to 1.99", and 6 $\geq$ 2".

2. Graduated markers in waste retention structures allow CAFO operators to know exactly how much liquid manure and/or process wastewater is in the waste treatment lagoon or waste storage pond. Waste retention structures must be maintained below the level designated in 40 CFR 412 to contain runoff from precipitation of a 25 year, 24-hour, or 100 year, 24-hour rainfall event as applicable. An NRCS designed waste retention structure that is maintained at the catastrophic storm storage level is not being operated as designed, i.e., maintaining the capacity to contain runoff and precipitation from a 25 year, 24-hour or 100 year, 24-hour rainfall event as applicable.

   a. Waste storage ponds should be dewatered to the sludge level during months with a crop water demand that could use the water for crop production. DO NOT EXCEED NUTRIENT APPLICATION RATES BASED ON THE SITE-SPECIFIC RISK ASSESSMENT METHOD OR THE HYDRAULIC LOADING RATES.

   b. Waste treatment lagoons should be maintained at or just above the minimum treatment volume during months with a crop water demand that could use the water for crop production. DO NOT EXCEED NUTRIENT

APPLICATION RATES BASED ON THE SITE-SPECIFIC RISK ASSESSMENT METHOD OR THE HYDRAULIC LOADING RATES.

3. The timing of nutrient application must correspond as closely as possible with plant nutrient uptake characteristics, while considering cropping system limitations, weather and climatic conditions, and field accessibility.

4. Avoid winter nutrient application for spring seeded crops.

H. Nutrient Application Methods

1. Except under conditions of agricultural storm water discharge as provided in 33 U.S.C. 1362(14), there must be no discharge of manure, litter, or process wastewater as a result of nutrient application by the CAFO. For example the direct discharge of to waters of the United States by spray irrigation.

2. Apply nutrient materials uniformly to application areas or as prescribed by precision agricultural techniques.

3. Consider immediate incorporation of land-applied manure, litter, sludge, and organic by-products to minimize risk of nutrient movement to surface waters.

4. Supplementary commercial fertilizer(s) and/or soil amendments may be added when the application of nutrients contained in manure and/or process wastewater alone is not sufficient to meet the soil and crop needs, or when a nutrient excess occurs such that other nutrients become unavailable to the plant or toxic conditions arise.

5. Process Wastewater Irrigation - Process wastewater application is not the same as irrigation. Process wastewater application scheduling should be based on the nutrient needs of the crop, the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil. Process wastewater application via irrigation must be at rates that minimize transport of sediment, nutrients, and chemicals to waters of the United States. The amount of water applied to the field should be measured and natural precipitation should be accounted for.

I. Setbacks and Vegetated Buffers

1. A setback distance from conduits to surface water must be maintained unless the CAFO uses either one of the compliance alternatives: vegetated buffer or alternative practices.

2. Setback - means a specified distance from waters of the United States or potential conduits to such waters where manure, litter, and process wastewater may not be land applied, but where crops may continue to be grown. The minimum width of a setback is 100 feet. Examples of conduits to waters of the United States include, but are not limited to: open tile line intake structures, sinkholes, karsts, ditches, cisterns and agricultural wellheads.

3. Vegetated Buffer - means a narrow, permanent strip of dense perennial vegetation, where no crops are grown, established parallel to the contours of and perpendicular to the dominant slope of the field for the purposes of slowing water runoff, enhancing water infiltration, trapping pollutants bound to sediment, and

minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching waters of the United States. The minimum width of vegetated buffer is 35 feet. On a per foot basis, it is more effective at reducing runoff than the setback. Vegetated buffers include NRCS Codes 332, 386, 391, 393, and 601. To the extent possible, the use of native vegetation should always be considered.

4. The minimum widths of setbacks and vegetated buffers must be **doubled** around a **sole-source drinking water supply wellhead**.

5. As a compliance alternative, the CAFO may demonstrate that a setback or buffer is not necessary because the implementation of alternative conservation practices of field-specific conditions will provide pollutant reductions equivalent or better than the reductions that would be achieved by the 100-foot setback.

6. Practices and management activities for vegetated buffers

   a. Removal of vegetation in vegetated buffers will be in accordance with site production limitations, rate of plant growth, and the physiological needs of the plants.

   b. Do not mow below the recommended height for the plant species.

   c. Maintain adequate ground cover and plant density to maintain or improve filtering capacity of the vegetation

   d. Maintain adequate ground cover, litter, and canopy to maintain or improve infiltration and soil condition.

   e. Periodic rest from mechanical harvesting may be needed to maintain or restore the desired plant community following episodic events such as drought.

   f. When weeds are a significant problem, implement pest management to protect the desired plant communities.

   g. Prevent channels from forming.

J. Considerations

[*High-quality soils prevent water pollution by resisting erosion, absorbing and partitioning rainfall, and degrading or immobilizing agricultural chemicals, manure, litter, process wastewater or other potential pollutants.*]

1. Conditions of the soil

   a. Because most coarse-textured soils have a low cation exchange (nutrient-holding) capacity, consider applications of manure, litter, sludge, process wastewater, and other organic by-products be restricted to several small applications during the growing season to minimize the chance of soluble nutrients reaching the ground water.

b. Nutrient application on soils with less than 20 inches in depth to parent material, according to the Cooperative Soil Survey, shall not exceed the one year phosphorus application rate.

c. Do not apply manure, litter, sludge, process wastewater, or other organic by-products over bedrock outcrops.

d. Do not apply manure, litter, sludge, process wastewater, or other organic by-products on soils where the rock fragments in the top five feet of the surface layer are 3 - 10 inches in diameter and exceed 50% by volume.

e. Do not apply manure, litter, sludge, process wastewater, or other organic by-products on soils where the rock fragments in the top five feet of the surface layer are >10 inches in diameter and exceed 25% by volume.

f. Do not apply manure, litter, sludge, or process wastewater, or other organic by-products on soils where the slope is >15% according to the Cooperative Soil Survey.

2. Saline soil

a. Balance soil fertility to allow plant roots to grow through saline layer.

b. If available, irrigation water may be used to leach salts below the root zone. Schedule salt leaching events to coincide with low residual soil nutrients and pesticides.

c. Use of nutrient sources with high salt content will be minimized unless provisions are used to leach salts below the crop root zone.

d. Micronutrients have a low availability on saline soils. Work to balance nutrients in the soil.

e. On sites where there is a high soil salinity is a concern, the potassium application rate should not exceed 100% of the requirement needed over the entire crop rotation, or three years for perennial crops.

f. On sites with pH values exceeding 8.5, consider adding gypsum to increase the availability and utilization of nutrients by the crop.

3. Alkaline soil

a. Alkaline soils have a high pH (above 7.0). This high pH is usually the result of too much calcium, potassium, sodium, or magnesium.

b. Micronutrients such as iron, manganese, boron, and zinc are sparingly available in alkaline soils, leading to deficiencies in plants. Work to balance nutrients in the soil.

c. Phosphorus deficiency may appear in plant tissue analyses as a result of little or too much phosphorus in the soil. **Do not** over apply phosphorus as determined by one of the risk assessment methods identified in V.F.1.and 2. above.

d. On alkaline soils, potassium should be applied near the time needed by the crop to minimize leaching.

e. Calcium carbonate accumulations that inhibit root growth for some plants are common in many low-rainfall alkaline soils. This calcareous layer helps maintain high pH levels and constrains the availability of micronutrients. Balance the soil to optimize plant growth and nutrient uptake.

4. Flooded ground (*Flood irrigation is not a part of this definition*)

a. Nutrient, solid or liquid, shall not be applied to flooded soils.

b. Agricultural waste shall not be land-applied on soils that are frequently flooded, as defined by the National Cooperative Soil Survey, during the period when flooding is expected.

c. Manure, litter, sludge, process wastewater, and/or other organic by-products may be applied to occasionally flooded areas during seasons when flooding is not expected and actively growing vegetation is present on over 50% of the field.

5. Saturated ground

a. Liquid manure and process wastewater shall not be applied on saturated soil where the manure or process wastewater may discharge to waters of the United States. The rate of application for liquid manure or process wastewater application on unsaturated soils shall not exceed the infiltration rate and moisture holding capacity of the soil after taking the antecedent moisture and temperature of the soil into account.

b. Avoid soil compaction on soils with high moisture content.

6. Drainage management

Subsurface drainage expedites the transport of nitrate-nitrogen from the soil zone with the result that a significant amount of unused nitrogen (nitrate N) from farm fields ends up in nearby streams and other surface waters.

a. The use of cover crops to utilize residual nitrates is recommended.

b. Fields that are subsurface (tile) drained require additional precautions. When liquid wastes are applied to fields with subsurface (tile) drains, the liquid can follow soil macropores directly to the tile drains, creating a surface water pollution hazard from direct tile discharge.

i. Do not apply application rates (volume) that would exceed the lesser of the available water capacity (AWC) in the upper 8 inches, or 13,000 gallons/acre per application. See Appendix E, **Available Water Capacity (AWC) Practical Soil Moisture Interpretations for Various Soils, Textures, and Conditions to Determine Liquid Waste Volume Applications not to Exceed AWC, to Determine AWC** and the amount (volume) that can be applied to reach the AWC.

ii. Prior to manure application, use a tool that can disrupt/close (using horizontal fracturing) the preferential flow paths (worm holes, cracks, root channels) in the soil, or till the surface of the soil 3 -5 inches deep to a condition that will absorb the liquid wastes. The purpose is to have the surface soil act as a sponge to soak up the liquid manure and keep it out of preferential flow channels. This is especially important if shallow tiles are present (<2 feet deep). Any pre-application tillage should leave as much residue as possible on the soil surface. The absorption of liquid manure by the soil in the root zone will minimize nitrogen loss and the manure/nutrient runoff potential. For perennial crops (hay or pasture), or continuous no-till fields where tillage is not an option, all tile outlets from the application area are to be plugged prior to application.

iii. If injection, is used, inject only deep enough to cover the manure with soil. Till the soil at least 3 inches below the depth of injection prior to application, or all tile outlets from the application area are to be plugged prior to application.

iv. In addition to tillage prior to surface liquid waste application or injection, install in-line tile flow control structures or inflatable tile plugs that can mechanically stop or regulate tile flow either prior to application, or have on site if needed to stop tile flow. Use caution not to back tile water where it may impair the functioning of an offsite subsurface drainage system.

v. Repair broken tile or blowholes prior to application.

c. In fields with existing drainage tiles, consider retrofitting to alternative water table management practices such as controlled drainage, subirrigation, and wetland reservoir subirrigation systems.

d. The incorporation of BMPs like riparian zones, denitrifying ponds, and wetlands to reduce the level of nitrates before discharge into ditches and streams is encouraged.

e. Design new subsurface drainage systems to manage soil water and water table levels through controlled drainage or subirrigation, lowering concentrations on nitrate-N in shallow ground water.

7. Drought

a. Cropping systems should be managed to maximize nutrient uptake from the soil and protect the soil during periods when erosion and potential nutrient runoff occurs.

b. Decrease nutrient application rates on non-irrigated areas when drought conditions occur.

c. Decrease grazing pressure pastures to maintain desired plant community and vegetation height.

d. Maintain adequate pasture conditions. This will maximize nutrient uptake by pasture plants and reduce nutrient flow into waterways. Overstocking pasture is a sure way to damage water quality. Overstocking damages plants, which reduces nutrient uptake and increases risk of erosion.

e. Reducing stocking rates and grazing pressure is key to managing native rangeland and tame pastures both during and after drought. High stocking rates during drought can prompt a change in the plant community, reduce plant litter and organic matter, increase bare ground, and remove vegetation needed to trap manure solids and nutrient bearing sediment, which can decrease water infiltration from precipitation and increases runoff.

8. Frozen ground

a. Frozen ground is any portion of the 0 - 6 inch soil layer (root depth) that is frozen.

b. Irrigation of wastewater to snow covered or frozen ground is prohibited

c. Adequate manure storage volume shall be provided and maintained to prevent the necessity of land applying manure on frozen and/or snow covered ground. No later than October of each year, the CAFO shall evaluate the storage capacity in their manure storage or treatment facilities and determine what steps are needed to avoid the need to land apply manure on frozen or snow covered fields for the upcoming winter. The operating record for the facility shall include documentation of the storage level as well as what was considered in this evaluation, and what actions were taken to avoid the need for land application of manure on frozen or snow covered ground.

d. Winter application of manure, litter, and other solid waste products is not desirable because nutrients cannot soak into frozen ground and manure accumulated on the surface of frozen soil or snow can easily be carried off the field during snow melt or other runoff events. In nutrient **non-impaired** watersheds, if winter applications must be made, applications may only be made under the following conditions: The application does not exceed the one year phosphorus rate, the field has a slope not greater than 6%, cool-season crops are present and actively growing in the field, nutrients are needed to be supplied to the crop, and erosion and runoff control practices are installed to minimize risk of nutrient movement. When choosing a location for winter application; fields that are furthest from streams and waterbodies must be used first. In nutrient **impaired** watersheds, application of manure, litter, or other solid waste products to snow covered or frozen ground is prohibited.

9. Heavy metals

a. Plans developed for nutrient management that include the use of manure or other organic by-products will recognize that some manures contain heavy metals and should be accounted for in the plan for nutrient management.

b. When sewage sludge is applied, the accumulation of potential pollutants (including arsenic, cadmium, copper, lead mercury, selenium, and zinc) in soil shall be monitored in accordance with the US Code, Reference 40 CFR, Parts 403 and 503, and/or any applicable State and local laws or regulations.

K. Plans and Specifications

1. Plans and specifications shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose(s), using nutrients to achieve production goals and to prevent or minimize water quality impairment.

L. Operation and Maintenance

1. Periodically conduct leak inspections of equipment used for land application of manure, litter or process wastewater.

2. Application equipment should be regularly (at least annually) calibrated to deliver the intended application rate and to achieve a uniform distribution pattern

   a. Equipment used to apply solid waste from dairy and beef should be calibrated to deliver within ± 2 ½ tons of the intended application rate.

   b. Equipment used to apply solid waste from swine should be calibrated to deliver within ± 1 ton of the intended application rate.

   c. Equipment used to apply solid waste and litter from poultry and foul should be calibrated to deliver within ± 1 ton of the intended application rate.

   d. Equipment used to apply organic by-products and solid waste from other animals should be calibrated to deliver within ± 1 ton of the intended application rate.

   e. Equipment used to apply liquid or slurry waste should be calibrated to deliver 10 percent of the intended application rate.

   f. Process wastewater irrigation rate is characteristic of sprinkler hardware and operating parameters (i.e., nozzle type, size, trajectory, and pressure). Hence, irrigators should be selected to be compatible with soil infiltration rate or permeability. If irrigator application rate is higher than soil infiltration rate, the possibility for runoff is increased. Since runoff must be prevented when irrigating process wastewater, it is recommended that irrigators be selected for the lowest application rate possible.

3. Records specified in this technical standard and in permit terms corresponding to 40 CFY 412.37(b) and (c) shall be maintained on-site for five years, or for a period longer than five years if required by other federal, state, or local ordinances, or program or contract requirements. These records must be available to the permitting authority and the Regional Administrator, or his or her designee, for review upon request.

4. When cleaning equipment after nutrient application, remove and save fertilizers or waste in an appropriate manner. The saved residue material may be utilized on another crop as part of the fertilization program outlined in the NMP. If the equipment is flushed, keep wastewater away from high runoff areas, ponds, lakes streams, wells, and other water bodies.

5. Dispose of fertilizer containers according to any applicable label directions and federal, state, and local laws.

V. Additional Considerations

A. Consider induced deficiencies of nutrients due to excessive levels of other nutrients.

B. Consider additional practices to improve soil nutrient and water storage, infiltration, aeration, tilth, diversity of soil organisms, and to protect and improve water quality.

1. Conservation Cover (327)

2. Grassed Waterway (412)

3. Contour Buffer Strips (332)

4. Filter Strips (393)

5. Irrigation Water Management (449)

6. Riparian Forest Buffer (391A)

7. Conservation Crop Rotation (328)

8. Cover and Green Manure (340)

9. Residue Management (329A, 329B, 329C, and 344)

10. Waste Utilization (633)

C. Consider cover crops whenever possible to utilize and recycling residual nitrogen.

D. Consider application methods and timing that reduce the risk of nutrients being transported to ground and surface waters, or into the atmosphere. Suggestions include;

1. Split applications of nitrogen to provide nutrients at the times of maximum crop utilization.

2. Avoiding winter nutrient application for spring seeded crops.

3. Band applications of phosphorus near the seed row.

4. Applying nutrient materials uniformly to application areas or as prescribed by precision agricultural techniques, and/or

5. Immediate incorporation of land applied manures or organic by-products.

6. Delaying field application of animal manures or other organic by-products if precipitation capable of producing runoff and erosion is forecast within 24 hours of the time of the planned application.

E. Consider the immediate incorporation of manures into the soil after application to reduce nitrogen volatilization losses associated with the land application of animal manures. Volatilization losses can become significant, if manure is not incorporated immediately after application.

F. Consider using soil test information no older than one year when developing new plans, particularly if animal manures are to be a nutrient source.

G. Consider annual reviews to determine if changes in the nutrient budget are desirable (or needed) for the next planned crop.

H. On sites on which there are special environmental concerns, consider other sampling techniques. (For example: Soil profile sampling for nitrogen, Pre-Sidedress Nitrogen Test (PSNT), Pre-Plant Soil Nitrate Test (PPSN) or soil surface sampling for phosphorus accumulation or pH changes.)

I. Consider ways to modify the chemistry of animal manure, including modification of the animal's diet to reduce the manure nutrient content, to enhance the producer's ability to manage manure effectively.

VI. Implementation

A. A new source CAFO shall attain implementation of this technical standard as of the date the NPDES permit is issued.

B. An existing CAFO shall attain implementation of this technical standard according to a schedule identified by the permitting authority. The schedule for implementation of this technical standard shall not extend beyond December 31, 2006.

APPENDIX P - CALCULATIONS FOR ESTIMATING MEDIAN ANNUAL OVERFLOW VOLUMES AND ANNUAL AVERAGE DISCHARGE OF POLLUTANTS

The methodology for estimating overflows is presented in the following seven steps:

1. Each day over the 25-year period, EPA subtracts the evaporation from the precipitation to calculate the net precipitation. The net precipitation is multiplied by the pond 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. The runoff volume is calculated by subtracting 0.5 inches of infiltration from the daily precipitation and multiplying by the drylot runoff area. If precipitation less 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. The daily volume of the pond is calculated by summing the net precipitation volume, the runoff volume, and the previous day's pond volume.

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

   The minimum pond volume is equal to the accumulated solids volume plus the minimum treatment volume. If there is no precipitation, the net precipitation volume will be negative and the runoff volume will be assumed to be zero. However, the pond volume can not be less than the accumulated solids volume. Therefore, anytime a net precipitation volume loss results in the daily pond volume being less than the accumulated solids volume plus the minimum treatment volume, EPA assumes the daily pond volume is equal to the maximum accumulated solids volume plus the minimum treatment volume.

4. During the freeze-free period, EPA assumes liquid from the pond is applied to crop land at a specified period (e.g., every 7 days, every 30 days, every 180 days).

   Applications (applications / yr) = Freeze Free Days (days / yr) / Days Between Application (days / application)

5. The amount of liquid per application is assumed to be equal to the estimated daily flow into the pond (from the cost model) multiplied by 365 days and divided by the number of annual applications.

   Liquid per Application (cf / application) = Estimated Daily Flow (cf / day) * 365 (days) / Applications (applications / yr)

6. EPA uses freeze free days to estimate a start day for application. The pond volume is never allowed to drop below the sludge volume plus the minimum treatment volume. If the application volume is greater than the volume available in the pond, EPA assumes all available liquid is applied.

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

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

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

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

Example for KT Pork Producers, Dubuque, IA

KF Pork Producers (KFP) is located in Dubuque County, Iowa. EPA uses 25-year daily precipitation and evaporation data from the Centerville, Iowa weather station to represent the climate of this county. The Centerville weather station is the closest weather station to Dubuque County, Iowa with readily available 25-year climate data. The climate data begins January 1, 1970 and ends December 31, 1995.

On January 1, 1970, KFP assumes the volume of was in the pond is equal to the sludge volume plus the minimum treatment volume which is 1,206,083 cubic feet (cf). It is assumed that the pond volume is never less than the accumulated solids volume plus the minimum treatment volume.

On January 2, 1970, the Centerville weather station reports 0.00 inches of precipitation and 0.0778 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 (cf) = (0.00 - 0.0778) * 157,272 / 12 = -1020 cf
Runoff Volume = 0
Previous Volume = 1,206,083
Daily Pond Volume = -1020 + 0 + 1,206,083 = 1,205,063 cf

KFP applies liquids in the holding lagoon to crop land every 7 days during the freeze free period between April 21 and September 14, provided that there has been no significant precipitation during the 3 days prior to the day of application. If there has been significant precipitation, the application date is moved to the next available date. In some cases this may mean that the weekly application may not occur.

The freeze free period for Dubuque County, Iowa is 147 days from April to September. This results in 21 applications per year.

Applications (applications / yr) = Freeze Free Days (days / yr) / Days Between Application (days / application)

Where:
Freeze Free Days = 147
Days Between Application = 7
Applications = 147 / 7 = 21 applications / year

Liquid per Application (cf / application) = Estimated Daily Flow (cf / day) * 365 (days) / Applications (applications / yr)

Where: Estimated Daily Flow = 8,356 cf/day
Liquid per Application = 8,356 * 365 / 21 = 145,235 (cf / application)

KFP's first day of application is April 21, 1970. In addition to adding the net precipitation and runoff volume to the previous volume, the application volume is subtracted April 21 and roughly every seventh day afterward until there are 21 applications. When overflow is calculated, the volume of the overflow is subtracted from the previous days pond volume.

On April 21, 1970, there is no precipitation and 0.349 inches of evaporation for Centerville, Iowa.

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

Where: Net Precipitation Volume (cf) = (0 - 0.349) * 157,272 / 12 = -4,574 cf
Runoff Volume = 0
Previous Volume = 776,594
Application Volume = 145,235
Daily Pond Volume = -4,574 + 0 + 776,594 - 145,235 = 626,785 cf

EPA estimates an average annual overflow for KFP to be 158,419 cf or 1,184,970 gal/yr over the 25-year period.

Using sampling data, the annual pollutant discharges are calculated by multiplying the overflow volume by the concentration:

Pollutant discharge (lbs/yr) = Pollutant concentration (mg/L) * 3.785 L/gal * Overflow volume (gal/yr) * 2.2 lbs/kg * 1 kg/10^6 mg