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TASK 3- IDENTIFY POTENTIAL WASTE MANAGEMENT PRACTICES REDUCING AMMONIA AND VOCs

LIVESTOCK WASTE MANAGEMENT PRACTICES SURVEY & CONTROL OPTION ASSESSMENT

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TASK 3

IDENTIFY POTENTIAL WASTE MANAGEMENT PRACTICES REDUCING AMMONIA & VOCs

Contract #01226

Table of Contents

- 1.1. Dairy House Keeping & Best Management Practices including Manure Removal Frequency, Stockpile Reduction, & Stockpile Covers
- 1.2. Nutrition & Ration Management
- 1.3. Milking Frequency
- 1.4. Covered Wastewater Lagoons
- 1.5. Storage Lagoon Covers including Biomass Blankets, etc.
- 1.6. Wastewater Constructed Wetlands Treatment
- 1.7. Biological & Microbial Additives
- 1.8. Chemical Additives

2. Off-Dairy Control Measure Effectiveness Calculations
   - 2.1. Land Application with Best Management Practices
   - 2.2. Dairy Relocation Outside Southern California Air Basin
   - 2.3. Young Stock Relocation Outside Southern California Air Basin
   - 2.4. Composting Within Southern California Air Basin
   - 2.5. Composting Outside Southern California Air Basin
   - 2.6. Regional or On-Site Anaerobic Digestion Systems
   - 2.7. Regional High Technology Manure Processing Facilities
   - 2.8. Manure Drying-Combustion-Energy Production Systems

3. Criteria For Assessing Emission Factors

A. SUMMARY

This report summarizes the potential control technologies and farm waste handling practices that could reduce ammonia and VOC emissions from dairy waste in the South Coast Air Basin.

Conclusions- The conclusions from work completed in Task 3 include the following.

Regarding the sources of emissions from dairies:

1. The largest source of dairy ammonia emissions was from dry corrals area- average 61%.
2. The second largest source was from feed lanes at an average 17% followed by ponds & stockpiles at about 10% each.
3. The third largest source was from dry manure land application ammonia emission reported at a range of 23% to 70% of ammonia excreted.
4. No reliable source emission information on VOCs was found.

Regarding the potential ammonia emission control measures:

1. A total of 29 potential control measures were identified.
2. A total of 22 potential control measures were found for on-dairy applications. The list is provided in Table 2.
3. A total of seven potential control measures were found for off-dairy applications. These include relocation; land application; composting {enclosed ASP, open ASP, open windrow}; anaerobic digestion systems; high tech drying/combustion systems.

Regarding the estimated removal effectiveness, in order of importance, the highest value net ammonia removal effectiveness were:

1. Daily feed lane cleaning associated with treatment control measure such as enclosed composting or anaerobic digestion- 30% net
2. Dairy relocation- averaging 2% per year
3. Nutrition & ration management- range of 5% to 30%
4. Stockpile elimination- 20% net
5. Wastewater wetlands treatment- 5% net

B. TASK 3– IDENTIFY POTENTIAL WASTE MANAGEMENT PRACTICES REDUCING AMMONIA & VOCs

Overall Approach- The purpose of this report is to identify potential waste management practices to reduce ammonia and non-methane volatile organic compounds.

Background – Scope of Work The scope of work for this report includes identification of potential control technologies and farm waste handling practices that could reduce ammonia and VOC emissions from dairy waste in the South Coast Air Basin (Basin). This task brings together information from the literature research conducted in Task 2.

Sequence of Activities The sequence of activities for this task began with research results for ammonia emissions collected by Charles Schmidt and Eric Winegar under contract to SCAQMD. Data from Task 2 was reviewed and summarized into a table of potential control measures. In conclusion, each of the potential control measures was researched in sufficient detail to summarize its estimated ammonia control effectiveness.

Description of Methodology & Techniques The methodology and techniques associated with this task are described in the relevant sections of the report.

Sources of Dairy Ammonia Emissions- This portion of Task 3 identifies and quantifies the sources of ammonia emissions from various locations on the dairies in the Basin. This information is important in order to summarize the net removal effectiveness associated with a particular control measure.

The locations on the dairies are defined in the following list. Field screening identified unique surface areas of a dairy where emissions were possible. These unique areas were included in the sampling strategy and are described below. Locations on the dairy are shown graphically in Figure 1.

MILK COW/DRY COW CORRAL, FULL SUN DRY MANURE: The corral is the location where milk cows reside when not being milked (most of the time) and dry cows reside when not in pasture (if pasture is available). The milk cow corrals are large, typically 5,000 to 11,000 m2 for milk cows and smaller for dry cows. Most of the surface area in the corrals are exposed to the sun and are covered with 1”-to-6” of dry manure. As the corral is populated with fresh manure, the fresh manure dries quickly and is soon pulverized into dry, unconsolidated manure. Other unique surface areas in the corrals include: shade area (or over-head water spray lines for cow temperature control), feeder area, water trough area, and thicker manure area. The corrals are scraped clean one or more times per year. Representative areas of dry manure (full sun) were sampled in both milk and dry cow corrals at each dairy tested. The surface area of the corrals tested were estimated by subtracting all other unique surface area estimates from the gross dimensions of the corrals tested.

TABLE 1_- DAIRY SOURCES OF AMMONIA EMISSIONS

LOCATION ON THE DAIRY	# DATA POINTS	RANGE OF AMMONIA EMISSION CONTRIBUTIONS*		AVERAGE	COMMENTS
		Summer	Winter		
1. Milking Center (rinsate)	1	0%	NM	0%	
2. Feed Apron	14	1.5%-66.6%	3.8%-41.6%	17%	
3. Dry Corral-open area	76[1]	33.4%-90.2% 50+%**	58.4%-96.2%	61%	
4. Dry Corral-stockpile (disturbed)	5	0%-20.6%	0.2%-29.9%	10%	
5. Stockpile (undisturbed)	4	0%-83.8%	4.3%-68.3%		
6. Flood Irrigated Pasture Land	1	NM	56.8%		
7. Waste Water Storage Ponds	6	8.3%-10.7%	14.7%-19.6%	12%	
8. Truck Transfer Vehicles	0	NM	NM		
9. Spray Irrigated Pasture Land	0	NM	NM		
	TOTAL OF CALCULATED AVERAGES			100%	

Data Sources: *- Schmidt & Winegar, 1996; **- Schmidt, Lester, & Winegar, 1999 from USDA AAQTF

MILK COW/DRY COW CORRAL SHADE AREA: All milk cow corrals sampled and most dry cow corrals sampled had overhead awnings for shade. The dimensions of the awnings were measured and reported as the surface area of the shade per corral.

MILK COW/DRY COW CORRAL FEEDER (APRON) AREA: All corrals tested used feed aprons with head-gates for cow feeders. Typically, one side of a corral along a center alley was constructed

[1] Combines various data points from Schmidt & Winegar research including Corral Dry + Corral Fresh + Corral Shade + Thick Disturbed + Thick Undisturbed + Water Trough

with feeders. Most feed aprons were concrete lined and generally were about 15' wide. The surface area of the wet manure (moisture possibly from water trough, fresh manure with higher moisture content, and urine) was estimated as a strip 9' wide in the apron for the length of the feed apron. Only 9' of the apron was used in the surface area estimate because the first 6' of the apron typically had little or no manure (head end).

MILK COW/DRY COW CORRAL WATER TROUGH AREA: All corrals were equipped with automatic water troughs for cow watering. It was typical to find areas around the water trough with moist manure. The manure can be wet from urine and fresh manure (since the areas are often visited by cows) and water from the trough (either leakage or cow activity in the trough). Moist manure surface around water troughs was variable and was estimated per corral tested.

MILK COW/DRY COW CORRAL THICK MANURE AREA: All corrals had areas with thicker layers of manure. Thick layers in corrals may have been the result of scraping the feed lane or may be associated with manure removal practices. Thick manure layer surface area were estimated per corral tested. Measurements were made on undisturbed thick areas representing the emission characteristic for most of the time, and on disturbed thick manure representing manure as it is handled.

MILK COW/DRY COW CORRAL FRESH MANURE AREA: Fresh manure was tested as a unique surface area per corral. The surface area of fresh manure was estimated by observing the frequency of cow defecation and the size of fresh manure areas. The procedure for estimating this surface area is provided in Table 3 and is meant to be an approximation for a surface found in the corrals tested. This source is insignificant compared to other sources.

DAIRY RINSATE: All dairies are required by law to wash cows prior to milking to remove manure from the cow udder. Rinsate is channeled typically by surface drains and subsurface sewers to liquid storage ponds. One dairy had an open area where rinsate could be tested prior to entry into the sewer system. The rinsate was tested and the surface area of the rinsate was estimated.

LIQUID STORAGE PONDS: Liquid storage ponds store the liquid waste from the milk parlor where the liquid is lost by evaporation or is used to irrigate pasture. All ponds were tested at one location by suspending the flux chamber from a small boom arrangement. The surface area of the ponds was measured at the time of testing. The volume of liquid in the ponds and thus surface area is dependent on the time of year (evaporation rate) and the water use demand.

STOCKPILES OUTSIDE OF CORRALS: Stockpiles outside of corrals were common to the dairies tested. The use of stockpiles, and also the size and age of stockpiled manure, is dependent on the economics of manure removal. Most dairies clean corrals twice per year: spring, when manure is dry enough to handle; and fall, in preparation for winter. Most dairies prefer not to stockpile out of the corral since this means that the manure will have to be handled twice versus one (i.e., twice the cost). Measurements were made on undisturbed stockpiles representing the emission characteristic most of the time, and on disturbed stockpiles representing manure as it is handled.

DAIRY PASTURE: A few dairies have pasture. Pasture is typically irrigated using milk parlor rinsate and fertilized using stockpiled waste. Cows also fertilize pasture as they graze. Pastures were encountered and tested at two dairies. The surface area of the pasture was estimated at the fenceline (Schmidt & Winegar, 1996).

Volatile Organic Compounds (VOCs)

An overview of studies of VOCs emitted from animal facilities indicates that hundreds of volatile organic compounds are present including volatile fatty acids, amines, alcohols, aliphatic aldehydes, p-cresol, indole, skatole, or mercaptans. In a recent analysis of VOCs emitted from swine facilities in North Carolina utilizing gas chromatography and mass spectrometry (GC/MS), over 300 compounds were identified. Many more compounds were present, but the GC peaks were too small to allow identification. The compounds identified by GC/MS were diverse and included many acids, alcohols, aldehydes, amides, amines, aromatics, esters, ethers, fixed gases, halogenated hydrocarbons, hydrocarbons, ketones, nitriles, other nitrogen-containing com-pounds, phenols, sulfur-containing compounds, steroids and other compounds. Acids, phenolic compounds and aldehydes were present in the highest concentrations (Schiffman et al, 2001).

The magnitude of total VOCs associated with animal feeding operations and/or waste management systems varies widely from as low as 0.60 mg/m^3 in a recently cleaned swine facility to 108 mg/m^3 from the headspace of a chamber containing slurries produced by weaner pigs. The effect of a large number of VOCs in aggregate is cumulative. Exposure to low concentrations of hundreds of compounds simultaneously can produce high levels of odor and irritation downwind of CAFOs. Introduction of irritant compounds into the upper and/or lower respiratory tract has been found to produce many systemic responses including altered respiration (Schiffman et al, 2001).

List of Potential Ammonia Emission Control Measures- This portion of Task 3 identifies the potential control measures for reducing ammonia associated with dairy production facilities and related activities. Table 2 shows options for on-dairy and off-dairy measures. Each of these measures is described in detail in the attached appendices. Several major categories of measures were identified for this report.

House Keeping & Best Management Practices -- more frequent corral cleaning, manure harvesting, and manure removal as well as eliminating manure stockpiles or reducing duration of stockpiling.

Ration/Diet Manipulation -- reduced protein levels; improved carbohydrate, nitrogen and sulfur utilization; synthetic amino acid supplementation; improved energy balances

Manure treatment -- aerobic conditions in surface manure (feedlots); wetlands treatment; lightly-loaded facultative lagoons; multiple stage lagoons; surface aeration of lagoons or storage pits; experimental biochemical amendments; composting; anaerobic digestion systems; high-tech manure processing; drying-combustion-energy production

Manure Management-- land application

Capture And Treatment Of Emitted Gases -- reduced liquid manure surface area; wet or dry scrubbers; dust control; biofilters; lagoon or storage pits covers; chemical oxidant surface sprays; non-thermal plasma reactors

Relocation- whole dairy or young stock

TABLE 2- LIST OF POTENTIAL AMMONIA EMISSION CONTROL MEASURES
ON-DAIRY OPTIONS
1. House Keeping & Best Management Practices
1.1. More frequent corral cleaning & manure removal
1.2. Eliminating manure stockpiles/reducing duration of stockpiling
1.2.1. Stockpile covers
2. Nutrition/Ration management
2.1. Use of somatotropin
2.2. Crude protein reduction
2.3. Rumen degradable protein reduction & utilization improvement
2.4. Multiple feed management strategies reducing manure pH
3. Wastewater covered anaerobic digester lagoons
4. Wastewater storage pond covers
4.1. Biofilter biomass blankets
4.2. Leca Rock
4.3. Plastic Covers
4.4. Concrete & Covered Tanks
5. Wastewater wetlands pond treatment
6. Biological/Microbial additives
7. Chemical additives
OFF-DAIRY OPTIONS
1. Land Application with Best Management Practices
1.1. Inside SoCal Air Basin
1.2. Outside SoCal Air Basin
2. Dairy Relocation
2.1. Young stock relocation outside SoCal Air Basin
2.2. Dairy relocation outside SoCal Air Basin
3. Composting Inside SoCal Air Basin
3.1. Enclosed ASP
3.2. Open ASP
3.3. Open Windrow
4. Composting Outside SoCal Air Basin
4.1. Enclosed ASP
4.2. Open ASP
4.3. Open Windrow
5. Regional anaerobic digestion systems
6. Regional high-tech manure processing
7. Drying-combustion-energy production

Summary of Estimated Removal Effectiveness for Control Measures: On-Dairy- This portion of Task 3 identifies the estimated removal effectiveness of the on-dairy control measures evaluated in this study. Table 3 shows the summary of the effectiveness calculations.

Regarding the estimated removal effectiveness on the dairy, in order of importance, the highest value net ammonia removal effectiveness was:

1. Daily feed lane cleaning associated with treatment control measure such as enclosed composting or anaerobic digestion- 30% net

2. Nutrition & ration management- range of 5% to 30%

3. Wastewater wetlands treatment- 5% net

Summary of Estimated Removal Effectiveness for Control Measures: Off-Dairy- This portion of Task 3 identifies the estimated removal effectiveness of the off-dairy control measures evaluated in this study. Table 4 shows the summary of the effectiveness calculations.

Regarding the estimated removal effectiveness off the dairy, in order of importance, the highest value net ammonia removal effectiveness was:

1. Dairy relocation- averaging 2% per year

2. Stockpile elimination- 20% net

TABLE 3. SUMMARY OF ESTIMATED REMOVAL EFFECTIVENESS FOR ON-DAIRY AMMONIA & VOC CONTROL MEASURES

CONTROL MEASURE TITLE	EST. SOURCE SIZE AS % OF TOTAL DAIRY EMISSIONS*	EST. CONTROL MEASURE REMOVAL EFFECTIVENESS		AP-42 APPROACH RATING A-E	ESTIMATED NET REMOVAL EFFECTIVENESS		CONSTRUCTION-OPERATIONS-MAINTENANCE ASSESSMENT	DESCRIPTION, ANALYSIS & COMMENTS
		AMMONIA	VOCs		AMMONIA	VOCs		
ON-DAIRY HOUSEKEEPING & MANAGEMENT PRACTICES								***Ammonia Only**
1. Daily feed apron cleaning & manure removal	61%	50%	VOC removal is effective although precise data is lacking	B	30%	30%		Midwest Plan Service, 1985; Minnesota Environmental Quality Board, University of Minnesota, 1999; Effective treatment management via enclosed anaerobic digestion or composting must be linked to this activity to achieve these results
2. Stockpile life reduction	10%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		
3. Stockpile covers	10%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		

4. Stockpile elimination	10%	100%	100%	D	10%	10%		
PRODUCTION, NUTRITION, & RATION MANAGEMENT								
1. Increase milking frequency from 2 to 3 times/day	70%	7%	Reliable information unavailable	D	5%	No Estimate At This Time		Dunlap, et al, 2000, J. Dairy Science
2. Use of hormone somatotropin	70%	12%	Reliable information unavailable	B	8%	No Estimate At This Time		U. S. Congress, Office Technology Assessment, 1993 derived from Bauman, 1990, White Paper
3. Reduce crude protein	100%	28%+	Reliable information unavailable	D	28%	No Estimate At This Time		Klausmer, et al, 1998, J. Production Agriculture; James, et al, 1999, J. Dairy Science; Smits, et al, 1998, Dairy Science.
4. Feed management via amino acids	70%	26%+	Reliable information unavailable	D	18%	No Estimate At This Time		Rogers, et al, 1989, Dairy Science; Dinn, et al, 1998, Dairy Science
5. Targeted feed mgt. via production grouping	70%	6%+	Reliable information unavailable	D	4%	No Estimate At This Time		St. Pierre & Thraen, 1999, J. Animal Science; Jonkers, et al, 2002, Dairy Science
6. Combined feed management strategies-hormones, photoperiod, & frequency	100%	16%+	Reliable information unavailable	D	16%	No Estimate At This Time		Dunlap, et al, 2000, J. Dairy Science;

7. Total Mix Ration feeding system	70%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		
STORAGE POND COVERS								
1. Biomass (straw) Biofilter	11%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		(straw, cornstalks, etc.) Crop residue is blown on surface of storage units typically to a depth of 8 to 10 inches Straw : about 2¢/ ft^2 + blower and labor.
2. LECA (light expanded clay aggregate) rock	11%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time	Lifetime appears to be several years. Care must be taken during agitation and pumping. Field experience is limited to date. .$1.50/$ft^2$	Light weight, volcanic rock (pebble sized) with hard coating keeps rock afloat. Layer of about 4 inches produces an acceptable cover

3. Plastic or Polymer (foam, geotextile & polyethylene) cover	11%		Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time	Potential problems with gas trapped under the cover, ballooning of the cover, and resulting wind damage. Bleeding off of trapped gas is essential.	Floating covers and covers placed on tent like structures Plastic covers will last 5 to 7 years with little maintenance.
4. Concrete covered tanks	11%		Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time	Concrete will last 20+ years with no maintenance.	Confined space can create life-threatening risk during human entry. Reinforced or pre-stressed concrete in below ground tanks.
MANURE & WASTEWATER TREATMENT								
1. Anaerobic Lagoons (uncovered)	11%	Emits significant quantities of ammonia	Emits significant quantities of VOCs	Not applicable	Not applicable	Not applicable		
2. Purple Bacteria Lagoon	11%	Emits significant quantities of ammonia	Emits significant quantities of VOCs	Not applicable	Not applicable	Not applicable		Photosynthetic purple bacteria use sulfides and volatile organic acids for metabolic processes resulting in odor & VOC emissions

3. Anaerobic digestion	61%	50%	50%	B	30%	30%	High maintenance requirements and knowledgeable operator is essential for successfully operated system. Cost and complexity of system is major impediment.	Methane fuel results from process and can be used for heat or electrical generation.
4. Aerobic Lagoons (oxidation pond)	11%	May emit quantities of ammonia	May emit quantities of VOCs	Not applicable	Not applicable	Not applicable		
5. Wastewater wetlands treatment	11%	48%	Reliable information unavailable	C	5%	No Estimate At This Time		Humenik, 2001, Midwest Plan Service
6. Additives Chemical	variable	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		Chemical products either fed to animal or added directly to the manure.
7. Additives Biological	variable	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		Microbial products either fed to animal or added directly to the manure. Widely variable information suggesting no clear, reliable performance

TABLE 4. LIST OF POTENTIAL OFF-DAIRY CONTROL MEASURES

CONTROL MEASURE DESCRIPTION	SOURCE SIZE AS % OF TOTAL DAIRY	CONTROL MEASURE REMOVAL EFFECTIVENESS		AP-42 APPROACH RATING	NET REMOVAL EFFECTIVENESS		CONSTRUCTION -OPERATION- MAINTENANCE	ANALYSIS & COMMENTS
		AMMONIA	VOCS		AMMONIA	VOCS		
Dairy relocation & animal reduction	100%	100%	100%	NA	100%	100%		Voluntary or business decision
Young stock relocation	100%	100%	100%	NA	100%	100%		Voluntary or business decision
LAND APPLICATION								
Inside SoCal Air Basin using BMP's	45%	50%	Reliable information unavailable	B	22%	No Estimate At This Time		
Outside SoCal Air Basin using BMP's	45%	100%	100%	B	45%	45%		
COMPOSTING INSIDE SOUTHERN CALIFORNIA AIR BASIN								
Enclosed ASP	60-100%	75%	80%	B	34% to 56%	36% to 60%		

Open windrow	60-100%	0%	Reliable information unavailable	B	0%	No Estimate At This Time		
COMPOSTING OUTSIDE SOCAL AIR BASIN								
Enclosed ASP	60-100%	75%	80%	B	34% to 56%	36% to 60%		
Open windrow	60-100%	0%	Reliable information unavailable	B	0%	No Estimate At This Time		
REGIONAL ANAEROBIC DIGESTION SYSTEMS								
IEUA System	61%	50%	50%	B	30%	30%		
REGIONAL HIGH TECHNOLOGY PROCESSING								
Drying-combustion	60-100%	Reliable information unavailable	Reliable information unavailable	E	No Estimate At This Time	No Estimate At This Time		

C. REFERENCES

1. Schmidt, C. E., Winegar, E., 1996, Technical Report- Results of the Measurement of PM10 Precursor Compounds from Dairy Industry Livestock Waste: Summer Testing Event and Winter Testing Event, South Coast Air Quality Management District, Diamond Bar, CA

2. Schiffman S. S., Auvermann, B. W., Bottcher, R.W. 2001; Health Effects Of Aerial Emissions From Animal Production And Waste Management Systems in White Paper Summaries National Center for Manure and Animal Waste Management, December 11, 2001.

3. Battye, R. Battye, W., Overcash, C., Fudge, S., 1994, Development and Selection of Ammonia Emission Factors, USEPA Contract #68-D3-0034, Research Triangle Park, North Carolina.

D. APPENDICES

4. On-Dairy Control Measure Effectiveness Calculations
    4.1. Dairy House Keeping & Best Management Practices including Manure Removal Frequency, Stockpile Reduction, & Stockpile Covers
    4.2. Nutrition & Ration Management
    4.3. Milking Frequency
    4.4. Covered Wastewater Lagoons
    4.5. Storage Lagoon Covers including Biomass Blankets, etc.
    4.6. Wastewater Constructed Wetlands Treatment
    4.7. Biological & Microbial Additives
    4.8. Chemical Additives

5. Off-Dairy Control Measure Effectiveness Calculations
    5.1. Land Application with Best Management Practices
    5.2. Dairy Relocation Outside Southern California Air Basin
    5.3. Young Stock Relocation Outside Southern California Air Basin
    5.4. Composting Within Southern California Air Basin
    5.5. Composting Outside Southern California Air Basin
    5.6. Regional or On-Site Anaerobic Digestion Systems
    5.7. Regional High Technology Manure Processing Facilities
    5.8. Manure Drying-Combustion-Energy Production Systems

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.1– CONTROL MEASURE EFFECTIVENESS CALCULATION – DAIRY HOUSEKEEPING & BMP

TABLE OF CONTENTS

I. Manure Harvesting / More Frequent Corral Cleaning

A. *Description including source size*- In this measure, the dairy operator removes manure and urine more frequently than is he currently does. The animal excretes the majority of its nitrogen in its urea. This nitrogen hydrolyzes very rapidly into ammonia gas. To the extent that the manure and urine can be removed for additional treatment, capture, dispersal transport from the basin, the ammonia & VOC's emission will be less.

The source size for corral cleaning is the largest single source on the dairy. The open area of the corral is estimated to contribute an average of 61% of the overall ammonia emissions at the Inland Empire dairies.

B. *Supporting Literature / Data*- The supporting literature and data for this control measure is sparse. No literature or research has directly measured the effectiveness of this control measure.

The USDA Agricultural Air Quality Task Force (AAQTF), 2000, observed that "much of the nitrogen excreted by cattle is in the form of urea. This urea will rapidly hydrolyze to ammonia and may volatilize. Mirocrobial degradation of fecal matter (manure) releases ammonia. Ammonia evolution rates are a function of time, temperature, pH and the level of microbial activity.

Sweetun, et al, 1999, reported that dairy corral ammonia losses by volatilization are 50% or more of the total N excreted. Keck, et al, 1997 reported that urine caused 8 times greater ammonia emissions per unit area than feces. The determining factors influencing ammonia emission included manure removal frequency, climate, and the exposed surface area. Keck concluded for dairy operations in the Netherlands that dairy manure removal yielded a small decrease in ammonia emissions versus removal on 3-day intervals. The ammonia emissions Keck observed were greater during warm seasons rather than cold season. Keck observed that reducing a dairy's surface area covered with manure decreased ammonia emissions. Bottye, et al, 1994, reported that factors influencing ammonia emissions at livestock operations included the type and size of animal, the nitrogen and amino acid content of the ration or feed, the digestibility and conversion of the nitrogen in the feed, the housing system, and the manure handling system. No details were given to support the contributions of individual component to ammonia and VOC emissions.

C. *Information Quality Rating*- The information available in support of this control measure is rated “E”. There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the size of this source on dairies in the Inland Empire, the opportunity for a positive impact from more rapid or frequent manure removal appears high.

II. Stock Pile Elimination / Reduction

A. *Description including source size*- Manure stockpiles on dairies have been a common practice. Data indicates that manure stockpiles are a significant ammonia source, on the average about 10% of the total ammonia emitted. Several data points indicate this value could be dramatically higher (up to 84%).

Recent experience on dairies in the Inland Empire has indicated significant reduction in manure stockpiles. The Santa Ana Regional Water Quality Board (SARWQCB) in 1999 adopted ordinances regulating manure management and stockpile removal. Since that time, dairies under compliance orders have removed manure stockpiles and cleaned their corrals of manure at least twice annually. These conditions are significantly improved over the base year, 1995 conditions

B. *Supporting Literature / Data*- The supporting literature for this control measure is sparse. Schmidt and Winegar, 1996, made limited measurements of ammonia emission from undisturbed and disturbed stockpiles. Their data is attached to this report.

C. *Information Quality Rating*- The information available in support of this control measure is rated “D”. This conclusion was obtained because the database is small, it may not be representative of the industry, and the information is widely variable. This may mean questionable accuracy of the data, although there is no certain means of determining accuracy based on available data.

D. *Removal Effectiveness*- In the case of completely removing stockpiles, the removal effectiveness is likely to equal 100% for the source. The effectiveness of more frequently removing stockpiles, or cornering stockpiles is unknown.

E. *Calculation of Net Removal Effectiveness*- Completely eliminating manure stockpiles of dairies will result in the elimination of an ammonia and VOC emission source. Therefore, the net removal effectiveness is estimated to equal 10% of 100%, which equals 10%.

F. *Analysis & Comments*- None.

G. *Conclusions*- Sufficient data exists to supply an engineering estimate of the net removal effectiveness of the control measure. For ammonia, the net removal effectiveness is estimated to equal 10% of the ammonia measured on Inland Empire dairies

III. Stockpile Covers

A. *Description including source size*- Manure stockpiles on dairies have been a common practice. Data indicates that manure stockpiles are a significant ammonia source, on the average about 10% of the total ammonia emitted. Several data points indicate this value could be dramatically higher (up to 84%).

Recent experience on dairies in the Inland Empire has indicated significant reduction in manure stockpiles. The Santa Ana Regional Water Quality Board (SARWQCB) in 1999 adopted ordinances regulating manure management and stockpile removal. Since that time, dairies under compliance orders have removed manure stockpiles and cleaned their corrals of manure at least twice annually. These conditions are significantly improved over the base year, 1995 conditions

B. *Supporting Literature / Data*- The supporting literature for this control measure is sparse. Schmidt and Winegar, 1996, made limited measurements of ammonia emission from undisturbed and disturbed stockpiles. Their data is attached to this report.

C. *Information Quality Rating*- The information available in support of this control measure is rated “D”. This conclusion was obtained because the database is small, it may not be representative of the industry, and the information is widely variable. This may mean questionable accuracy of the data, although there is no certain means of determining accuracy based on available data.

D. *Removal Effectiveness*- In the case of completely removing stockpiles, the removal effectiveness is likely to equal 100% for the source. The effectiveness of more frequently removing stockpiles, or cornering stockpiles is unknown.

E. *Calculation of Net Removal Effectiveness*- Completely eliminating manure stockpiles of dairies will result in the elimination of an ammonia and VOC emission source. Therefore, the net removal effectiveness is estimated to equal 10% of 100%, which equals 10%.

F. *Analysis & Comments*- None.

G. *Conclusions*- Sufficient data exists to supply an engineering estimate of the net removal effectiveness of the control measure. For ammonia, the net removal effectiveness is estimated to equal 10% of the ammonia measured on Inland Empire dairies

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.2 – CONTROL MEASURE EFFECTIVENESS CALCULATION – NUTRITION / RATION MANAGEMENT

TABLE OF CONTENTS

I. Use of Somatotropin

A. *Description including source size* **-** Somatotropin is a natural protein hormone that exerts a key control over nutrient utilization in dairy cattle. Extensive research shows that Bovine somatotropin (BST), a synthetic protein markedly improves productive efficiency and reduces manure and urine excretion in lactating cows. Lactating cows constitute about 70% of the herd.

B. *Supporting Literature/Data*- Extensive, reputable research for over 30 years documents the safety and efficacy of BST. The value of a 12% increase in nutrient utilization and subsequent reduction in excretion has been extensively documented.

C. *Information Quality Rating*- The information in support of this control measure is rated "B".

D. *Removal Effectiveness*- The USDA Office of Technology Assessment reports a reasonable expectation that the herd would experience a 12% increase in nutrient utilization due to the use of somatotropin.

E. *Calculation of Net Removal Effectiveness*- The use of somatotropin occurs in the lactating portion of the herd, usually about 70% of the mature animals on the dairy. Twelve percent of 70% yields an 8.4% increase in nutrient utilization.

F. *Analysis & Comments*- Utilization of BST within the dairy industry in Southern California is unknown. Information supplied by industry representatives indicates its use is controversial. Additional comments were received indicating use of BST does not necessarily lead to reduction in manure and urine but instead maintains or may increase excretion due to dairy operator decisions to produce more milk rather than produce less manure.

G. *Conclusions*- Due to the relatively little information available on this option and its utilization in the Southern California dairy industry, it is not recommended for utilization in the AQMD program.

II. Reduction of Crude Protein

A. *Description including source size* – Reduction of crude protein in the cows diet is another of several techniques considered that focus on dietary management. The overall goal of diet management is to utilize precision feeding techniques that will meet the animal's nutrient requirements while minimizing excretion of nitrogen. Crude protein adjustment usually takes the form of manipulating the total mix ration via changes to soybean meal, blood meal or feather meal.

B. *Supporting Literature/Data*- Several studies of the impact and effectiveness of this option were reported in the literature. Research work on this issue appears to have been undertaken over the past 10-years with some in Europe and some in North America. This is not an extensive database of research information.

C. *Information Quality Rating*- The information available in support of this control measure is rated "D". This conclusion was obtained because the database is small, it may not be representative of the industry, and the information is widely variable.

D. *Removal Effectiveness*- The reported removal effectiveness from the research indicates a reduction in ammonia of 28% or more.

E. *Calculation of Net Removal Effectiveness*- Reduction of crude protein would occur over the total dairy herd, yielding a calculated 28% net removal effectiveness.

F. *Analysis & Comments*- Utilization of crude protein reduction within the dairy industry in Southern California is unknown.

G. *Conclusions*- Due to the relatively little information available on this option it is not recommended for utilization in the AQMD program.

III. Reduction of Rumen Degradable Protein & Utilization Improvement

A. *Description including source size* – Feed supplied to dairy cattle is categorized as degradable intake protein (DIP) or undegradable intake protein (UIP). Researchers have found that conditions related to the ratio between these criteria potentially effect the amount of nitrogen excreted by the cows. If the ratio between DIP and UIP is incorrect, it is highly likely that excess nitrogen will be excreted. Researchers have found that DIP may degrade too quickly to maintain proper balance within the animal thereby causing excess nitrogen excretion. Overall, these are extremely complex bio-chemical processes within the dairy rumen that makes it difficult to provide reliable predictive models.

B. *Supporting Literature/Data*- Several studies of the impact and effectiveness of this option were reported in the literature. Research work on this issue appears to have been undertaken over the past 10-years with some in Europe and some in North America. This is not an extensive database of research information.

C. *Information Quality Rating*- The information available in support of this control measure is rated "D". This conclusion was obtained because the database is small, it may not be representative of the industry, and the information is widely variable.

D. *Removal Effectiveness*- The reported removal effectiveness from the research indicates a reduction in ammonia of 16% or more.

E. *Calculation of Net Removal Effectiveness*- Reduction of degradable intake protein would occur over the total dairy herd, yielding a calculated 16% net removal effectiveness.

F. *Analysis & Comments*- Utilization of degradable intake protein reduction within the dairy industry in Southern California is unknown.

G. *Conclusions*- Due to the relatively little information available on this option it is not recommended for utilization in the AQMD program.

IV. Multiple Feed Management Strategies Reducing Manure pH

A. *Description including source size* – Researchers have postulated that it is possible to optimize the dairy cow metabolism through various feed management strategies that yield a reduction in pH and a consequent increased nutrient utilization within the cow and reduction in urea and manure excretion.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. No literature or research has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.3– CONTROL MEASURE EFFECTIVENESS CALCULATION – MILKING FREQUENCY

TABLE OF CONTENTS

I. Milking Frequency

a. *Description and Source Size*- In this measure, the dairy operator increases the frequency of milking from 2 times per day to 3 times per day.

b. *Supporting Literature / Data*- Sutton, et al, 2001 (National Canter for Manure & Animal Waste Management) reported that increasing the frequency of milkings would reduce the amount of nitrogen excretion and consequently the amount of ammonia that can be volatilized. The document is a summary of a White Paper in press. No additional information or data was supplied.

c. *Information Quality Rating*- The information available in support of this control measure is rated "E". At this time, there is no data on which to base emission factors or engineering estimates. The complete White Paper document will be published and made available by March 15, 2002.

d. *Removal Effectiveness*- Unknown.

e. *Calculation of Net Removal Effectiveness*- Unable to calculate the net removal effectiveness.

f. *Analysis & Comments*- If information supporting this control measure is available, the opportunity for emission control would be important.

g. Conclusions Due to the relatively little information available on this option it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.4 – CONTROL MEASURE EFFECTIVENESS CALCULATION – COVERED WASTEWATER LAGOONS

DATE:

Covered Wastewater Lagoon

A. *Description including source size* – Wastewater lagoons are a relatively rare component of dairy farming in the Southern California area. Dairy practices in this region are predominantly dry lot operation with lagoon systems in use only during rainfall events for control of potentially contaminated runoff. Within the dairy area only six out over 275 dairies were noted to have active flush systems that utilized wastewater lagoons.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any literature or research that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: **TASK 3 Appendix 1.5 – CONTROL MEASURE EFFECTIVENESS CALCULATION – STORAGE LAGOON COVERS INCLUDING BIOMASS BLANKETS, ETC.**

DATE:

Storage Lagoon Covers including Biomass Blankets, etc.

A. *Description including source size* – Several types of storage lagoon covers were noted through the literature research. Types that have been tested include biomass (straw), light expanded clay aggregate, foam or geotextile fabrics, or totally enclosed tanks. Overall, wastewater lagoons are a relatively rare component of dairy farming in the Southern California area. Dairy practices in this region are predominantly dry lot operation with lagoon systems in use only during rainfall events for control of potentially contaminated runoff. Within the dairy area only six out over 275 dairies were noted to have active flush systems that utilized wastewater lagoons.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any literature or research that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: **TASK 3 Appendix 1.6 – CONTROL MEASURE EFFECTIVENESS CALCULATION – WASTEWATER CONSTRUCTED WETLANDS TREATMENT**

DATE:

Wastewater Constructed Wetlands Treatment

A. *Description including source size* – Constructed wetlands treatment of dairy wastes is applicable only to the wastewater portion of the residuals. Overall, wastewater lagoons and wastewater residuals are a relatively rare component of dairy farming in the Southern California area. Dairy practices in this region are predominantly dry lot operation with lagoon systems in use only during rainfall events for control of potentially contaminated runoff. Within the dairy area, only six out over 275 dairies were noted to have active flush systems that utilized wastewater lagoons.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any literature or research that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated “E”. There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.7 – CONTROL MEASURE EFFECTIVENESS CALCULATION – BIOLOGICAL & MICROBIAL ADDITIVES

DATE:

Biological & Microbial Additives

A. *Description including source size* – There are a number of ways that have been suggested that could be used for addition of biological and microbial material to achieve a wide potential range of claims. In general they fall into two categories of feed additives or post excreta additives that act on the manure and or wastewater.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any credible literature or research (excluding vendor or manufacturer claims) that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 1.8 – CONTROL MEASURE EFFECTIVENESS CALCULATION – CHEMICAL ADDITIVES

Chemical Additives

A. *Description including source size* – There are a number of ways that have been suggested that chemicals could be used to achieve a wide potential range of claims. In general they fall into two categories of feed additives or post excreta additives that act on the manure and or wastewater.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any credible literature or research (excluding vendor or manufacturer claims) that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.1 – CONTROL MEASURE EFFECTIVENESS CALCULATION – LAND APPLICATION WITH BEST MANAGEMENT PRACTICES

A. *Description including source size* – Land application as a control measure can be effective. The practice should follow Natural Resources Conservation Service Conservation Practice Standard # 633- Waste Utilization. The size of the source in the case of Southern California dairies is approximately 60%.

As commercial fertilizer has reduced the need for manure, the economic benefit of manure has been increasingly viewed only in terms of the direct benefit associated with the essential nutrients for crop growth. This typically is measured in terms of the fertilizer replacement value. For example, an application of 10 tons of solid beef manure to an acre of land reduces fertilizer nitrogen requirements by about 40 lbs. during the next cropping year, which would save the farmer about $10 per acre at present fertilizer prices, disregarding the cost of manure application.

Utilization of manure applied to land is accomplished through microbial conversion of plant residues and wastes into usable crop nutrients. Breakdown of organic nutrient sources takes considerable time with only a fraction of the applied nitrogen being available the first year. Actual mineralization rates are difficult to determine given the fact that this is a biological process that is sensitive to temperature and moisture conditions found in the soil system. In manure, N is mostly organic and ammonium nitrogen. Organic N is a slow release N source. Ammonium N is equivalent to commercial fertilizer and, except for that lost to the air, can be used by plants in the application year. Organic nitrogen must be converted to inorganic form before plants can use it. Variable amounts of organic nitrogen are released to the soil in a plant-available form during the first cropping year after application. Organic N released during the second, third, and fourth cropping years after initial application is usually about 50%, 25%, and 12.5%, respectively of that mineralized during the first cropping season (MWPS, 1985).

Methods of application of manure are: broadcast (top dressed) with plow-down or disking, broadcast without plow-down or disking, knifed (wet manure injected under the soil surface), and irrigated (liquid manure).

The greatest nitrogen response follows land application and immediate incorporation into the soil. Best management practices recommend to plow down solid manure as soon as possible to minimize nitrogen loss and to begin release of nutrients for plant use. Most losses occur in the first 24 hours after application, so the most air quality benefit occurs when manure is incorporated into the soil as soon as possible. Injecting, chiseling, or knifing liquids into the soil minimizes odors and nutrient losses to the air and/or to runoff. Nitrogen loss as ammonia from land is greater during dry, warm, windy days than during humid or cold days. Ammonia loss is generally greater during the spring and summer months.

Use of manure should be based on at least one analysis of the material during the time it is to be used. In the case of daily spreading, the waste should be sampled and analyzed at least once each year. As a minimum, the manure analysis should identify nutrient and specific ion concentrations.

Where manures are to be spread on land not owned or controlled by the producer, the manure plan, as a minimum, should document the amount of manure to be transferred and who will be responsible for the environmentally acceptable use of the manure.

Additional description of the practice includes: All manure should be utilized in a manner that minimizes the opportunity for contamination of surface and ground water supplies. Where manures are utilized to provide fertility for crop, forage, fiber production, and forest products, the practice standard Nutrient Management (590) should be followed. Manures should be applied at rates not to exceed the crop nutrient requirements or salt concentrations as stated above, and should be applied at times the manures can be incorporated by appropriate means into the soil within 72 hours of application. The effect of Waste Utilization on the water budget should be considered, particularly where a shallow ground water table is present or in areas prone to runoff. Limit manure to the volume of liquid that can be stored in the root zone. Minimize the impact of odors of land-applied manures by making application at times when temperatures are cool and when wind direction is away from neighbors. Priority areas for land application of manures should be on gentle slopes located as far as possible from waterways. When manures are applied on more sloping land or land adjacent to waterways, other conservation practices should be installed to reduce the potential for offsite transport of manure. It is preferable to apply manure on pastures and hayland soon after cutting or grazing before re-growth has occurred. Reduce nitrogen volatilization losses associated with the land application of manure by incorporation within 24 hours. Minimize environmental impact of land-applied manure by limiting the quantity of manure applied to the rates determined using the practice standard Nutrient Management (590) for all waste utilization. The manure management plan is to account for the utilization or other disposal of all animal wastes produced, and all manure application areas shall be clearly indicated on a plan map. The operation and maintenance plan should include the dates of periodic inspections and maintenance of equipment and facilities used in manure utilization. The plan should include what is to be inspected or maintained, and a general time frame for making necessary repairs.

B. *Supporting Literature/Data*- Extensive, reputable research for decades documents the safety and efficacy of manure land application. The value of a 50% reduction in ammonia volatilization has been extensively documented in the case where the ammonia base quantity is that amount remaining in the manure at the time of land application.

C. *Information Quality Rating*- The information in support of this control measure is rated “B”.

D. *Removal Effectiveness*- The literature supports a removal effectiveness of 50% or greater of the ammonia remaining in the manure at the time of land application from land application when using best management practices. The amount of ammonia remaining in the manure is mostly a function of the amount of time that has passed for the bulk of the manure since it was deposited in the corral. Decay rate values for ammonia volatilization from corrals in Southern California are not available. Reasonable estimates appear to stand at about 25% of the ammonia volatilizing prior to the time the manure is removed for land application.

E. *Calculation of Net Removal Effectiveness*- The use of best management practices for land application of manure would apply to a source size of 60% of the dairy. Approximately 45 percent of the ammonia would remain yielding an 22% reduction in ammonia volatilization. Much of the manure land applied from Southern California is trucked outside the SC AQMD air basin. This portion of manure would yield about 45 percent reduction in ammonia volatilization.

F. *Analysis & Comments*- Utilization of manure land application within the dairy industry in Southern California is widespread. Over 75% of manure management currently is accomplished using this technique. The economics of transporting manure outside of the basin will be a factor in application of that particular option.

G. *Conclusions*- Utilization of manure land application is likely to remain as one of the major practices for Southern California dairy operators.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.2 – CONTROL MEASURE EFFECTIVENESS CALCULATION – DAIRY RELOCATION OUTSIDE SOUTHERN CALIFORNIA AIR BASIN

A. *Description including source size* – Relocation of dairies outside of the Southern California air basin would remove the cattle and related emissions from the area. It would transfer the emissions to other locations that may or may not have assimilative capacity to absorb these emissions. Removal of all animals would result in 100% source size.

B. *Supporting Literature/Data*- No formal literature exists documenting the relocation of dairies outside the basin. Information available from the California Department of Food and Agriculture indicates that dairy relocation is occurring at up to several percent per year. Data from the RWQCB indicates that the number of dairies in the region are relocating or reducing by a similar amount. Industry sources including the Milk Producers Council and Western United Dairymen indicate that dairy relocation will continue as an industry trend. These sources believe that an overall reduction of 50% from today's levels will occur during the next 20-years.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E".

D. *Removal Effectiveness*- The effectiveness of this control measure is 100% based on all animals leaving the basin.

E. *Calculation of Net Removal Effectiveness*-The net removal effectiveness would amount to 100% for the numbers of animals being removed.

F. *Analysis & Comments*- Significant new research and data development must be under taken to monitor and assess the effectiveness of this control measure.

G. *Conclusions*- Dairy relocation is a valid and consistently occurring process in the dairy industry.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.3 – CONTROL MEASURE EFFECTIVENESS CALCULATION – YOUNG STOCK RELOCATION OUTSIDE SOUTHERN CALIFORNIA AIR BASIN

A. Description including source size – Similar to the relocation of dairies outside of the Southern California air basin, removal of youngstock would remove the cattle and related emissions from the area. It would transfer the emissions to other locations that may or may not have assimilative capacity to absorb these emissions. Removal of all animals would result in 100% source size.

B. *Supporting Literature/Data*- formal literature exists documenting the relocation of dairies outside the basin. Information available from the California Department of Food and Agriculture indicates that dairy relocation is occurring at up to several percent per year. Data from the RWQCB indicates that the number of dairies in the region are relocating or reducing by a similar amount. Industry sources including the Milk Producers Council and Western United Dairymen indicate that dairy relocation will continue as an industry trend. These sources believe that an overall reduction of 50% from today's levels will occur during the next 20-years.

C. Information Quality Rating- The information available in support of this control measure is rated "E"..

D. *Removal Effectiveness*- The effectiveness of this control measure is 100% based on all animals leaving the basin.

E. *Calculation of Net Removal Effectiveness*- The net removal effectiveness would amount to 100% for the numbers of animals being removed.

F. *Analysis & Comments*- Significant new research and data development must be under taken to monitor and assess the effectiveness of this control measure.

G. *Conclusions*- Dairy relocation is a valid and consistently occurring process in the dairy industry.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.4 – CONTROL MEASURE EFFECTIVENESS CALCULATION – COMPOSTING WITHIN SOUTHERN CALIFORNIA AIR BASIN

A. Description including source size – Composting is the controlled decomposition of organic material under aerobic conditions. Under certain conditions, such as composting via aerated static pile, emissions from composting operations can be greatly reduced. The size of the source relative to manure management is a function of the timing of manure removal from the dairy. The source size for relatively dry corral manure is about 60% while fresh or daily removal could approach 100%.

In general, manure quality desired for composting is dry or about 60% solids. This quality is consistent with corral dry manure. Furthermore, it is consistent with dry corral manure management practices of removing manure twice annually. This practice complies with requirements of the RWQCB. The result of this manure management approach is that a significant proportion of the nitrogen and ammonia in the urea and manure will have volatilized while remaining in the dairy corral awaiting removal to the composting facility. An alternative for consideration by the dairies is to rapidly remove the manure for delivery to the composting facility.

Composting is a biological process in which organic matter (volatile solids) is degraded to a relatively stable humus-like material. Composting reduces manure volume. A study showed that approximately 50% of the carbon was lost from microbial respiration, which contributed to the overall volume reduction associated with composting. Manure composting can be either anaerobic or aerobic, but modern composting is usually limited to aerobic systems.

Objectives of composting are to:

- Stabilize putrescible organic matter.
- Kill pathogens and weed seeds.
- Conserve the nitrogen, phosphorus, potash, and resistant organic matter found in the raw material.
- Produce uniform, sterile, and relatively dry end produce, which free from odors.
- Conduct the process free from insects, rodents, and odors, and as inexpensively and dependably as possible.
- Produce a valuable fertilizer and soil conditioner.

Composting is a biological process and environmental factors influence organism activity and determine the speed and extent of the composting cycle. The most important factors are material particle size, moisture content, aeration, temperature, and initial carbon-nitrogen ratio. Ideally, the smaller particles, the greater the surface area, and the more access for the degrading organisms. Particle size may need to be reduced by grinding, such as crop residues like corn stalks.

The moisture content for optimum composting is 50%-60%, depending on particle size and aeration. If aeration is maintained, the moisture content can be above 60%. At high moisture content, voids fill up with liquids, and aeration is hindered. Low moisture levels retard or stop microbial activity, although some composting occurs with moisture as low as 25%. If adequate aeration can be maintained despite high moisture content, fresh animal manure can be composted directly because of favorable particle size. Over-aeration has no advantage and tends to reduce temperatures. Aeration can be accomplished by forced air or turning.

Three types of composting operations are available ranging from aerated windrows, aerated static piles (open or enclosed), to in-vessel. Aerated windrows are more suited to large volumes of organic material that are managed by power equipment used to turn the composting material periodically. Periodic turning re-aerates the windrows, promoting the composting process.

Organic material in aerated static piles is initially mixed to a homogeneous condition and not turned again throughout the composting process. Static pile material must have the proper moisture content and bulk density to facilitate air movement throughout the pile. Forced air is necessary to facilitate the composting process. ASP composting can economically occur either enclosed in a building or out of doors. In either case, where suction air is used, the air is typically captured and discharged through a biofilter for removal of odor, ammonia (routinely 75%), and volatile organic compounds (routinely 80%).

In-vessel composting in a totally enclosed structure is carried out on a blended organic material under conditions where temperature and air flow are strictly controlled. In-vessel composting also includes naturally aerated processes where organic materials are layered in the vessel in a specified sequence. Layered, in-vessel materials are usually turned once to facilitate the process. Vessel dimensions must be consistent with equipment to be used for management of compost.

B. *Supporting Literature/Data*- Extensive, reputable research for decades documents the efficacy of manure composting.

C. Information Quality Rating- The information available in support of this control measure is rated “B”.

D. Removal Effectiveness- The overall effectiveness of the control measure is a function of the type of composting system and related air control technologies. In the scenario where manure is removed to an ASP facility and all polluted air is processed in biofilter, the removal effectiveness can be routinely 75% for ammonia and routinely 80% for volatile organic compounds.

E. *Calculation of Net Removal Effectiveness*- the net removal effectiveness for ASP composting systems with biofilters can range from 34% to 60%.

F. *Analysis & Comments*- Composting of manure is a relatively common practice in Southern California with about 25% of the total volume of dry manure production being processed using the windrow composting technology. Windrow composting, the current process technique, does not provide additional ammonia and VOC reduction beyond the current year baseline.

G. *Conclusions*- Due to the size of this source on dairies in the Inland Empire, the opportunity for a positive impact from more rapid or frequent manure removal and effective composting appears high. The SC AQMD should consider this option for part of its dairy ammonia reduction program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.5 – CONTROL MEASURE EFFECTIVENESS CALCULATION – COMPOSTING OUTSIDE SOUTHERN CALIFORNIA AIR BASIN

A. Description including source size – Relocation of manure composting outside of the Southern California air basin would remove the manure and related emissions from the area. It would transfer the emissions to other locations that may or may not have assimilative capacity to absorb these emissions. Removal of all manure would result in 100% source size.

B. *Supporting Literature/Data*- Extensive, reputable research for decades documents the efficacy of manure composting.

C. Information Quality Rating- The information available in support of this control measure is rated "B".

D. *Removal Effectiveness*- The effectiveness of this control measure is a range from very little effectiveness (function of the removal frequency) to a high percent based on all fresh manure leaving the basin.

E. Calculation of Net Removal Effectiveness-The net removal effectiveness would amount to 100% for the manure being removed.

F. *Analysis & Comments*- Significant new research and data development must be under taken to monitor and assess the effectiveness of this control measure.

G. *Conclusions*- Manure removal is a valid and consistently occurring process in the dairy industry.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.6 – CONTROL MEASURE EFFECTIVENESS CALCULATION – REGIONAL OR ON-SITE ANAEROBIC DIGESTION SYSTEMS

A. *Description including source size* – Anaerobic digestion is a natural process that converts biomass to energy. Manure for digestion would come from the feed aprons at each dairy amounting to a source size of about 17%.

Biomass is any organic material that comes from plants, animals or their wastes. Anaerobic digestion has been used for over 100 years to stabilize municipal sewage and a wide variety of agricultural and industrial wastes. The anaerobic process removes a majority of the odorous compounds. It also significantly reduces the pathogens present in the slurry. Over the past 25 years, anaerobic digestion processes have been developed and applied to a wide array of industrial and agricultural wastes including dairy manure. It is the preferred waste treatment process since it produces, rather than consumes, energy and can be carried out in relatively small, enclosed tanks. The products of anaerobic digestion have value and can be sold to offset treatment costs.

Anaerobic digestion provides a variety of benefits including:

- Odors, ammonia, and VOCs are significantly reduced or eliminated.
- Flies are substantially reduced.
- A relatively clean liquid for flushing and irrigation can be produced.
- Pathogens are substantially reduced in the liquid and solid products
- Greenhouse gas emissions are reduced.
- Non-point source pollution is substantially reduced

The Inland Empire Utilities Agency as a part of its regional Organics Management Strategy is conducting demonstration projects of the effectiveness of anaerobic digestion systems to manage manure and related solids. IEUA commenced an Organics Management Study in August 2000 to address long-range plans for treating and utilizing biosolids as well as dealing with the problems of disposing of manure and green waste material generated within its service area. This resulted in the release of an Organics Management Strategy Business Plan dated May 31, 2001. The Business Plan summarized the technical facts and the process followed during the course of the Organics Management Study and proposed the evaluation of several sites and construction of digestion and composting facilities as necessary to meet the needs of the Agency.

B. *Supporting Literature/Data*- Extensive, reputable research for decades documents the efficacy of manure anaerobic digestion.

C. *Information Quality Rating*- The information available in support of this control measure is rated "B".

D. *Removal Effectiveness*- The overall effectiveness of the control measure is a function of the type of manure collection system, frequency of manure collection, type of digestion technology, and related air control technologies. The most likely scenario is one where manure is removed from the dairy to an anaerobic digestion facility on a daily basis. The AD facility processes the manure, generates methane gas, burns the gas to produce heat and electricity and the process air is treated in a biofilter, where the removal effectiveness can be routinely 75% for ammonia and routinely 80% for volatile organic compounds. This system has the potential to remove high quantities of ammonia and VOC as the fresh manure is removed daily from the feed aprons.

E. *Calculation of Net Removal Effectiveness*- the net removal effectiveness for anaerobic digestion systems with biofilters can range from 13% to 14%. [Note: daily manure removal associated with anaerobic digesters represents a near 100% removal of on-dairy emissions.]

F. *Analysis & Comments*- Significant new research and data development must be under taken to monitor and assess the effectiveness of this control measure.

G. *Conclusions*- Due to the size of this source on dairies in the Inland Empire, the opportunity for a positive impact from more rapid or frequent manure removal and effective anaerobic digestion appears high. The SC AQMD should consider this option for part of its dairy ammonia and VOC reduction program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.7 – CONTROL MEASURE EFFECTIVENESS CALCULATION – REGIONAL HIGH TECHNOLOGY MANURE PROCESSING FACILITIES

A. *Description including source size* – Various private vendors have proposed a range of potential technologies including gasification and fuel creation.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any credible literature or research (excluding vendor or manufacturer claims) that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

Southern California Air Quality Management District (SCAQMD)

SUBJECT: TASK 3 Appendix 2.8 – CONTROL MEASURE EFFECTIVENESS CALCULATION – MANURE DRYING-COMBUSTION-ENERGY PRODUCTION SYSTEMS

A. *Description including source size* – Various private vendors have proposed a range of potential technologies including pelletizing, drying to produce granules and various energy type projects.

B. *Supporting Literature/Data*- The supporting literature and data for this control measure is sparse. There does not appear to be any credible literature or research (excluding vendor or manufacturer claims) that has directly measured the effectiveness of this control measure.

C. *Information Quality Rating*- The information available in support of this control measure is rated "E". There are no data on which to base emission factors. Engineering estimates can not be established at this time.

D. *Removal Effectiveness*- The effectiveness of the control measure can not be determined due to lack of relevant data or information.

E. *Calculation of Net Removal Effectiveness*- Due to a paucity of data, the net removal effectiveness can not be calculated.

F. *Analysis & Comments*- Significant new research and data development must be under taken to assess the effectiveness of this control measure.

G. *Conclusions*- Due to the relatively little information available on this option and the very few dairies to which it would apply, it is not recommended for utilization in the AQMD program.

A. APPENDIX 3

CRITERIA FOR ASSESSING EMISSION FACTORS

This appendix describes the criteria that were used to assess the quality of the NH_3 emission factors presented in this report. The purpose of the ratings is to provide a qualitative indication of the reliability of the emission factors. Criteria used to assess the emission factors are listed below.

DISCUSSION OF CRITERIA

Emission Factor Development Methods: Most emission factors are determined from either source tests, industry surveys, mass balances, or engineering estimates. The accuracy of these methods depends on several different parameters which change from one emission source to another.

- **Source Tests:** In source testing, samples are taken directly from the source emitting the pollutant. Accurate approved test methods should have been used whenever possible. If an unapproved method or an outdated method was used, the quality of the emission factor should be questioned.

- **Industry Survey:** In a survey, EPA submits a series of questions to a plant or site that is emitting the pollutant in question. The plant or site personnel voluntarily fill out and return the questionnaire to the surveyor. To obtain accurate information, the questions must be worded carefully so that the correct and desired information may be considered accurate. To effectively assess the quality of an emission factor, the survey methodology should be known.

- **Engineering Estimate:** An engineering estimate is based on process information available to the engineer. The engineer makes several assumptions and with other available information, he estimates an emission factor. This method of determining an emission factor is generally the most inaccurate. However, with adequate background information, an accurate estimate can frequently be made.

Size of Database: The emission factor becomes increasingly accurate as the database from which the factor was determined expands. Emission factors constructed on information from one source have less credibility than those from several sources.

Database Represents a Good Cross Section of Industry: An average emission factor should be determined from as cross section of the industry. A good cross section is related to the size of the database. However, a large database does not ensure a good cross section, and an excellent cross section is possible from a small database.

Age of Data: Some emission factors quickly lose credibility for the following reasons:

- The sampling and testing methods may have been proven invalid, and as better methods are developed, inherent flaws in previously used methods are discovered.

- Technological innovations occur in most industries on a regular basis. Consequently, the process parameters used when the emission tests were performed may differ significantly from those currently used in the industry. Control systems may be more efficient, fuel feed and production rates may differ, the composition of pollutants may be significantly different, etc. As a result, the old emission factor may no longer apply.

- New laws and regulations may be passed which would significantly affect the emissions from a source.

RATING SYSTEM

A rating system, analogous to the *AP-42* system, was developed to grade each emission factor. Due to the variability in the type of information in the reference used to assign emission factors, a good deal of subjective engineering judgement was used in giving each factor a grade.

Emission factors for each process were given a rating of A through E, with the A rating representing the more reliable emission factor and the E rating a less reliable rating.

A qualitative description of each rating is listed below:

A Rating

- Large database from surveys or source tests on several different studies was used.
- Database covers a cross section of the industry.
- Emission factors were determined by mass balance based on sound measurement.

B Rating

- Database is fairly large; however, it is not clear that it represents a good cross section of the industry.
- Emission factor was measured using valid test methods at the time the test was performed. However, tests have since been revised.
- Engineering estimate based on sound, accurate information.

C Rating

- Database consists of a few good sources.
- Data may or may not be representative of the industry.
- Engineering estimates based on accurate information. However, information is not extensive or complete.

D Rating

- Database is small. If one sample, it was a representative site.
- Database may not be representative of industry.
- Unapproved test methods may have been used.

- Engineering estimates are based on information where accuracy is questionable.

E Rating

- Database is small. Results conflict with each other.
- Any sources tested are not representative of the industry.
- Engineering estimates are based on very little reliable information.

The above ratings are referred to throughout this report in the discussion of specific emission factors.

TASK 3

IDENTIFY POTENTIAL WASTE MANAGEMENT PRACTICES REDUCING AMMONIA & VOCs