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Feedlot Air Quality Summary:
Data Collection, Enforcement and Program Development

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EXECUTIVE SUMMARY

The Minnesota Pollution Control Agency (MPCA) Feedlot Air Quality Work Group has collected hydrogen sulfide and ammonia air data from around feedlot facilities in the state throughout 1998. The data was used for program development, research and enforcement. The following report is a summary of the data collection efforts, mitigation methods, enforcement, permitting and related environmental review. The Feedlot Air Quality Work Group has reviewed these efforts and make the following recommendations.

1 - Further research is needed in the following areas:

   a. to identify which factors may affect the animal unit/hydrogen sulfide ambient air concentration relationship.

   b. to determine if a relationship between hydrogen sulfide/odor emissions and animal species exists.

   c. to identify which animal housing and ventilation styles affect hydrogen sulfide and odor emissions.

   d. to determine if atmospheric emissions of ammonia need to be regulated in Minnesota.

2 - MPCA field staff need a more effective method of screening for ammonia emissions in the field.

3 - The MPCA, Counties and producers need further research into the effectiveness, management and cost of mitigation methods for hydrogen sulfide and odor.

The MPCA Feedlot Air Quality Work Group has also identified two objectives that will help advance the control of feedlot air emissions. The first objective is to foster the development of feedlot air quality control at the county level. The MPCA would supply technical and regulatory support to assist the counties in implementing and developing these programs. The second objective is to identify areas of scientific and administrative research that will further feedlot air quality control. This information will assist the MPCA, producers and local units of government to determine when mitigation or monitoring is necessary. Further research is necessary to develop this type of administrative tool. The MPCA will develop interim guidance during the research phase to assist in the feedlot permitting and environmental review process.

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I. INTRODUCTION

A. FEEDLOT AIR EMISSIONS AND AIR QUALITY

Air emissions from feedlots are a diverse group of gases and particles. At least four sources of feedlot air emissions have been identified. One source of emissions is the animal itself that is in part dependent upon diet and metabolism. Another source is the animal housing unit or barn that is closely related to the first emission source. The third emission source identified is the animal waste storage system and lastly, the land application of animal waste. While all of these emission sources present specific technical and regulatory issues regarding mitigation and measuring, this report focuses on the animal housing and waste storage systems as emissions' sources.

The emissions from the animal waste storage system are a result of the natural biological and bacterial activities that occur within the animal waste. Often times these emissions are referred to as "odor", however, the emissions contain many specific constituents such as hydrogen sulfide, ammonia, and methane. These air emissions have social and environmental effects locally, regionally and globally.

Historically, a common assumption has been that the only significant air quality issue associated with feedlots was nuisance odor. As a result, little or no attention was given to monitoring specific air pollutants emitted from feedlot facilities. In the past, the Minnesota Pollution Control Agency (MPCA) has viewed odors as a natural result of animal production that could best be addressed through good land use planning, with the primary responsibility for land use planning at the local level of government (see Minn. R. 7020.0100).

Regulating odor emissions is difficult. One of the problems relates to the varied perception of the term "odor". Researchers have indicated that the chemistry of feedlot odor may contain 168 separate chemical substances (O'Neill and Phillips, 1992). However, the composition of feedlot odor is variable and is governed in part by livestock species, management practices and manure storage method (Sutton, Kephart, et al., 1997; Macke and Van Den Weghe, 1997). Time of year and time of day may also be a factor in the composition of the emissions. This makes measurement of feedlot odor difficult as there is currently no generally accepted quantitative method. Most of the odor measurement conducted in this emerging science is related to experimental olfactory evaluations that employ individuals trained to smell the ambient air around feedlots and characterize the odor.

The lack of an adequate quantitative method to measure and evaluate odor is a major barrier in regulating these complex emissions. The MPCA encountered this dilemma when it proposed new odor control rules in 1995. The proposed rules were withdrawn for various reasons including the administrative resources available to properly enforce the rule (MPCA, 1996). The proposed rules were never intended to regulate odorous emissions from feedlots. The proposed language contained several exemptions for most agribusiness odorous emission sources.

While regulating odors is fraught with difficulty, methodology to accurately measure and control odorous feedlot emissions are emerging. The University of Minnesota is actively researching odor abatement technologies, along with odor measurement and related predictive tools. The Feedlot Manure Management Advisory Committee (FMMAC) has recommended several areas of research into odor control and management (LOTF, 1997). This research would provide technical and regulatory information to counties and townships to assist them in implementing odor control measures. The University of Minnesota has conducted various investigations related to the FMMAC recommendations and continues to research the measurement and control of feedlot odors.

As feedlot odor science evolves, the technology to accurately measure these emissions will develop. This will likely lead to a refinement in regulating these emissions. At this time, the State of Minnesota currently regulates feedlot air emissions through enforcement of the state hydrogen sulfide ambient air standard (Minn. R. 7009.0080). The state is also exploring the possibility of regulating ambient and atmospheric ammonia emissions from feedlot facilities.

The MPCA currently evaluates potential air quality impacts when conducting environmental review and permitting of feedlot facilities. If a facility has a potential to exceed the state hydrogen sulfide ambient air standards, or the Minnesota Department of Health's proposed health risk value (HRV) for ammonia, the company may be required to implement a preventative action to reduce emissions, and place continuous air quality monitors at the facility to determine compliance.

Minnesota is not alone in regulating feedlot air quality. In Europe, feedlot air emission regulation is primarily directed at controlling ammonia emissions through best management practices, building design and land application of manure. In the United States, several states are proposing feedlot air emissions' regulations including Idaho, Colorado and Nebraska. Some states have used common law nuisance actions to address the feedlot odor and dust issue. This method has encountered rigid barriers as a result of legislative exemptions. It appears that the laws in some states may be changing in favor of more stringent regulation. The Iowa Supreme Court has recently taken the lead in this area by declaring unconstitutional Iowa's statutory "nuisance immunity" - a major barrier to common law nuisance actions against livestock production facilities. *Bormann et al. v. Board of Supervisors in and for Kossuth County*, 584 N.W. 2d 309 (Ia. 1998).

The State of Minnesota is unique in that the air regulation program has evolved beyond the developmental stage into a functional feedlot air quality program that actively regulates feedlot air emissions through an ambient air quality standard. The MPCA initially developed the program to regulate hydrogen sulfide emissions from livestock facilities. This program has been integrated into the MPCA's Feedlot Lateral Team and addresses hydrogen sulfide emissions and related feedlot air quality issues through the MPCA's Feedlot Air Quality Work Group. The following sections illustrate the development of the Feedlot Hydrogen Sulfide Program and the transition to the Feedlot Air Quality Work Group.

B. THE FEEDLOT HYDROGEN SULFIDE PROGRAM

The Minnesota Legislature addressed the feedlot odor issue by enacting legislation requiring the MPCA to monitor hydrogen sulfide emissions from feedlot facilities and takes appropriate enforcement actions when facilities are found to be in violation of the state hydrogen sulfide ambient air standard (Minn. Stat. § 116.0713 (Supp. 1997)). The statute puts Minnesota at the national and international forefront of feedlot air quality regulation.

On July 1, 1997, the MPCA established the Feedlot Hydrogen Sulfide Team. This team is an interdisciplinary group of MPCA staff members formed to develop a hydrogen sulfide regulatory program through monitoring, research and related compliance and enforcement activities.

During the fall and winter of 1997 and early 1998, the Feedlot Hydrogen Sulfide Team developed several areas of the program including a complaint response system, a monitoring protocol for screening feedlot hydrogen sulfide emissions, and methods approved by the MPCA Commissioner to monitor compliance with the state hydrogen sulfide ambient air standard.

The MPCA Feedlot Hydrogen Sulfide Program began the 1998 monitoring season in late March. Feedlot facilities that received air monitoring during the 1998 season were selected as a result of citizen complaints; as a subject of an air quality computer model study, or as a control group site to assist the MPCA in evaluating emissions from various types of livestock operations. A total of 137 feedlot facilities were screened or monitored for the presence of hydrogen sulfide emissions during the 1998 monitoring season. Of the 137 feedlots monitored, 24 of these facilities have demonstrated a potential to exceed the state hydrogen sulfide ambient air standard. A complete discussion of these findings is found in the *1998 Feedlot Hydrogen Sulfide and Ammonia Field Data* Section on page 9 of this report.

Continuous air monitors were deployed at four facilities to monitor compliance with the state hydrogen sulfide standard. One of the facilities monitored exceeded the state hydrogen sulfide standard. A complete discussion is found in the *1998 Feedlot Hydrogen Sulfide and Ammonia Field Data* Section on page 16 of this report.

C. The Feedlot Air Quality Work Group

The MPCA underwent an extensive reorganization in the summer of 1998. One of the many changes the MPCA implemented was the creation of a Feedlot Lateral Team. The Feedlot Lateral Team is composed of various activities which include permitting, enforcement, technical assistance and outreach programs.

The Feedlot Hydrogen Sulfide Program was integrated into the Feedlot Lateral Team and a Feedlot Air Quality Work Group was created to address feedlot air quality issues.

The Feedlot Air Quality Work Group (Work Group) is composed of MPCA staff from various disciplines and areas of the agency. The Work Group is designed to address emerging and existing feedlot air quality issues and to provide technical and regulatory assistance to the Feedlot Lateral Team regarding air quality standards, permitting and environmental review. The Work Group will accomplish this task by working closely with MPCA and County feedlot staff, as well as partnering with various units of state and local government, and the University of Minnesota.

The Work Group has identified two objectives that will help advance the control of feedlot air emissions. The first objective is to foster the development of feedlot air quality control at the county level. The MPCA would supply technical and regulatory support to assist the counties in implementing and developing these programs. The second objective is to identify areas of scientific and administrative research that will further feedlot air quality control. This information will assist the MPCA, producers and local units of government to determine when mitigation or monitoring is necessary. Further research is necessary to develop this type of administrative tool. The MPCA will develop interim guidance during the research phase to assist in the feedlot permitting and environmental review process.

II. FEEDLOT HYDROGEN SULFIDE AND AMMONIA AMBIENT AIR DATA

A. 1998 FEEDLOT HYDROGEN DATA COLLECTION

1. State Hydrogen Sulfide Ambient Air Standard

The State of Minnesota has adopted ambient air quality standards for hydrogen sulfide, set forth in Minnesota Rule 7009.0080. The hydrogen sulfide ambient standards are as follows:

Pollutant/ Air Contaminant	Primary Standard	Remarks
Hydrogen sulfide	0.05 ppm* (50 ppb) by volume (70.0 micrograms per cubic meter)	one half hour average not to be exceeded over two times per year
	0.03 ppm*(30 ppb) by volume (42.0 micrograms per cubic meter)	one half hour average not to be exceeded over two in any five consecutive days

* Note: ppm means parts per million and ppb means parts per billion

Minn. R. 7009.0200 prohibits violation of these standards beyond the property line or in locations to which the general public has access. ("General public" does not include employees, trespassers, or persons authorized by the property owner to be on the property for a limited period of time and for a specific purpose.)

The field data accumulated throughout the 1998 monitoring season was collected for regulatory purposes to determine if a facility had a "potential to exceed" the state standards. A "potential to exceed" is defined as a one-half hour average concentration collected at the property boundary of a facility, or where the public has access, that is greater than 30 parts per billion. An actual violation of the state standards cannot be documented unless approved continuous air monitoring methods are used and the exceedances are recorded in excess of the frequency established by the standards. The following section provides a general overview of the methods and protocol used to collect hydrogen sulfide field data.

2. Description of Monitoring Methods

Minn. R. 7009.0060 requires that measurements made to determine compliance with hydrogen sulfide standards be performed in accordance with a method approved by the MPCA Commissioner.

As published in the State Register on January 5, 1998, the MPCA Commissioner approved two methods pursuant to Minn. R. 7009.0060 for measuring concentrations of hydrogen sulfide in the ambient air (MPCA, 1998). One type of monitor is the "total reduced sulfur system" known as a TRS monitor. This system is complicated and expensive but results in high quality data. It uses an EPA approved sulfur dioxide monitor with a thermal oxidizer unit to convert the reduced sulfur gases, of which hydrogen sulfide is the principle component, to a measurable form.

The other type of continuous monitor approved by the MPCA Commissioner is the MDA Scientific Chemcassette ® Model 7100 Model SPM sensitized paper tape monitor. This monitor is simple to use and less expensive to deploy than the TRS system. This system measure's hydrogen sulfide by quantifying the dark stain that the gas produces on a specially prepared paper tape inside the monitor. This type of sampler is available as a battery powered portable system and can be very convenient to deploy, it also has proven to be very reliable.

Continuous monitoring involves a considerable degree of effort including accessing a suitable site, conducting quality assurance activities, and analyzing a considerable quantity of data. Meteorological data is valuable and often gathered with continuous air monitoring data.

The MPCA also performs hydrogen sulfide emission monitoring for screening purposes. This is a non-continuous or "grab" type of sampling. The MPCA has found the "Jerome" 631-X gold film H_2S monitor (Jerome Meter) from Arizona Instruments to be suitable for this duty. It is a truly portable hand-held hydrogen sulfide gas analyzer. Its sensitivity and accuracy make it an excellent tool for ambient air screening work. Each unit includes a functional test module which can quickly determine that the unit is operating properly.

The Jerome Meter uses the principle of amalgamating the H_2S in the air with gold on a thin film within the monitor. The H_2S causes a change in the electrical resistance of the gold film that is calibrated to the H_2S concentration. This type of monitor has proven very sensitive and convenient to use. It has also enabled a large number of widely distributed sites to be screened in a short amount of time. Sampling with this type of monitor is a manual (non-automated) procedure and produces data only when the field scientist is at the site. However a site may be visited a number of different times during the monitoring season.

The "grab" type of sampling (with the use of a Jerome Meter) has proven useful as a site screening tool, although, the manner in which the MPCA hydrogen sulfide standard is written makes the "continuous" style of air monitoring (TRS and MDA equipment approved by the MPCA Commissioner) the only method for demonstrating compliance with the standard.

3. Jerome Meter Screening Protocol

During the 1998 monitoring season, all Jerome Meter data was collected near or beyond the property boundary of the facility being screened. This was determined by either consulting with the facility operator, county plat maps or with county feedlot officers in appropriate counties.

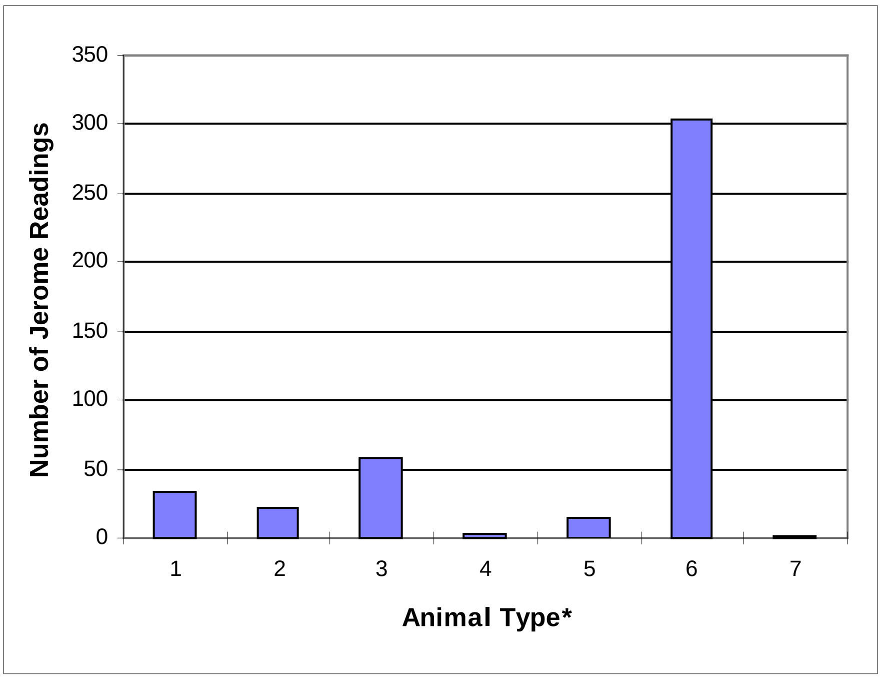
Once the property boundary was determined, air samples were randomly collected along this delineation to detect the main odor plume emanating from the facility. When this location was determined, screening commenced by collecting a total of 32 air samples during a one-half hour time period. The 32 samples were compiled by taking 16 pairs of 30 second samples, every 2 minutes, for one-half hour. These readings, along with meteorological data, animal type, manure storage method, and a sampling location sketch were recorded on a field data sheet. Meteorological data consisted of wind direction, wind speed, temperature, humidity, and barometric pressure.

Most of the air samples were collected on public roads or similar public access points. However, some data was collected on private property adjacent to a feedlot facility.

4. 1998 Jerome Meter Site Descriptions

Sites that were monitored during the monitoring season included an array of feedlot types and sizes. The types of feedlots monitored included: cattle feedlots with beef calves; cattle feedlots with feeder cattle; facilities with broiler chickens; facilities with layer chickens; facilities with chicken pullets; dairy facilities with dairy cows; dairy facilities with dairy youngstock; feedlots with sheep; feedlots with ducks; feedlots with turkeys; swine facilities with farrowing sows, gestation sows, breeder swine, nursery pigs, finishing hogs and feeder pigs. Figure #1 separates the number of Jerome Meter readings by specific livestock species. The size of all feedlots monitored using the Jerome Meter ranged from 2 to 20,000 animal units (au). Table #1 illustrates specific livestock species and their animal unit equivalents.

Figure #1 - Number of Jerome Meter Readings versus Livestock Species Type



***1**= beef **2**= chicken **3**= dairy **4**= ducks/geese **5**= turkey **6**= swine **7**= sheep

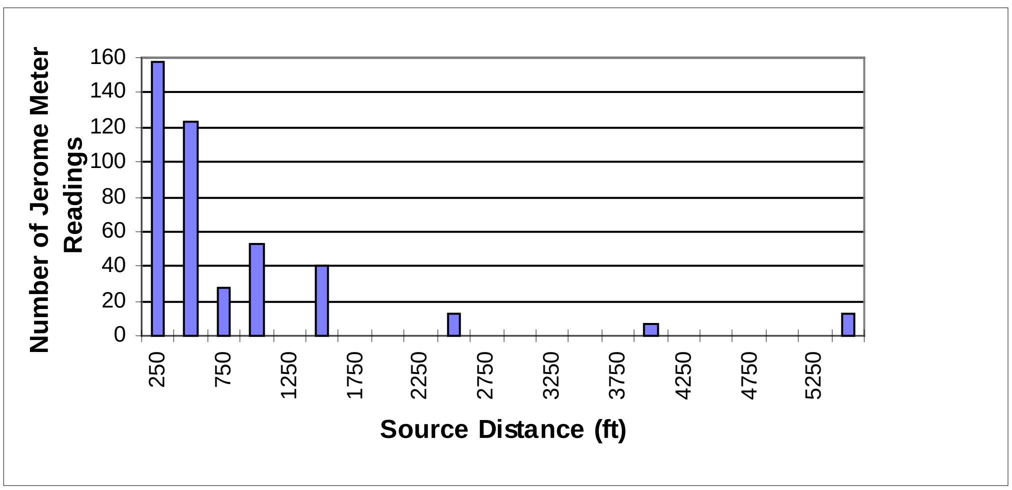
Table #1
Animal Unit (au) Equivalents

Turkeys	0.018 au
Ducks	0.2 au
Geese	0.2 au
Chickens	0.01 au
Cattle	1.0 au
Dairy Cows	1.4 au
Sheep	0.4 au
Swine	0.4 au

The distance from the source of hydrogen sulfide to the monitoring site location varied from 10 feet to 5,300 feet. The spatial variation was related to field logistics such as the distance between the emission source, the property boundary, and location accessibility (Figure #2).

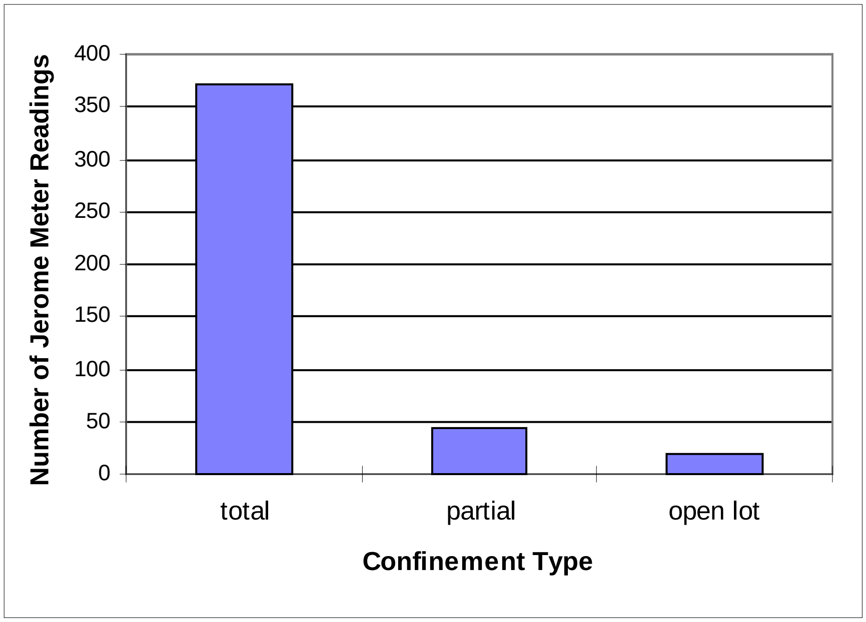
MPCA staff attempted to gather field data that would reflect predicted diurnal emission variation. Therefore, field data was gathered at various times of the day and evening hours.

Figure #2 - Number of Jerome Meter Readings versus Approximate Source Distance



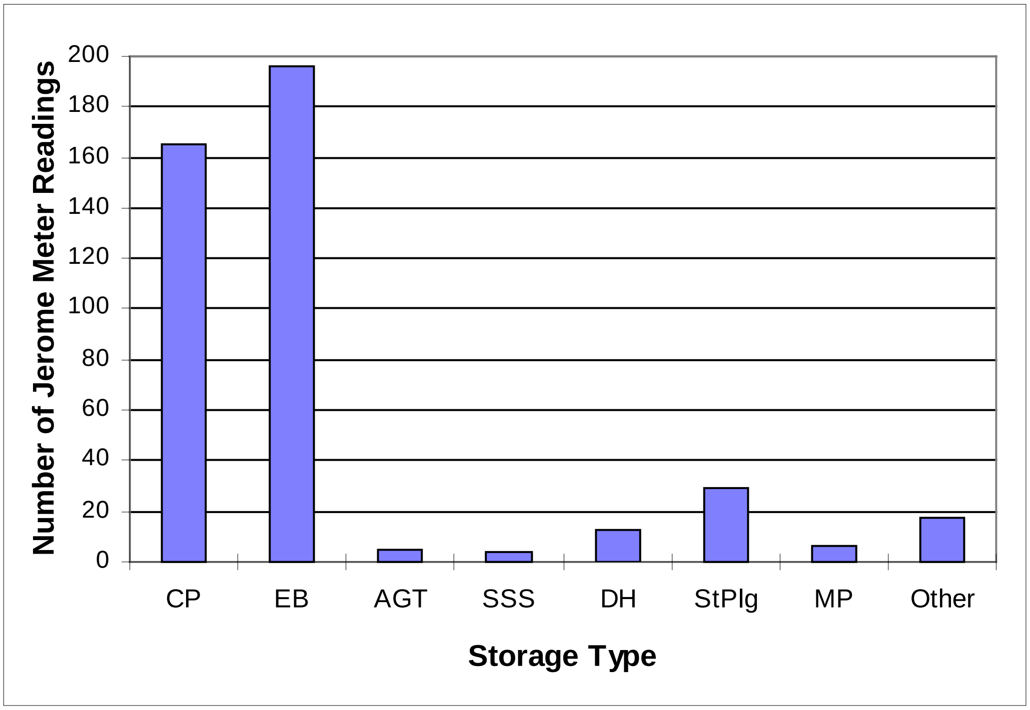
Three distinctive styles of animal confinement systems were monitored by the MPCA: total confinement units, partial confinement units, and open lot systems. A total confinement unit is a barn system in which the livestock are raised in an enclosed structure typically throughout the entire lifecycle of the animal. Animal waste is typically stored in concrete pits beneath the barn or in large earthen storage structures. A partial confinement unit is an animal housing system where animals can leave the shelter of the barn and walk outside, typically into an open lot. Animal waste is either removed from the site on a regular basis, stored in concrete pits beneath the animal enclosure or stored in an earthen storage system. Open lot systems, the third style of livestock management system monitored by the MPCA, is a simple system where an open lot is enclosed by a fence. Typically, waste is removed from an open lot system on a regular basis through a "scrape and haul" process. This style of livestock production typically does not contain an animal enclosure on the site (Figure #3). The most frequently monitored facilities were total confinement units, with partial confinement units the second, and open lot systems third.

Figure #3 - Number of Field Samples versus Animal Confinement System Type



The MPCA monitored a variety of manure storage methods around the state. These included concrete pits (typically beneath the total confinement unit buildings), earthen storage systems, above ground concrete and steel manure storage tanks, solid stacking slabs, daily haul management (no structure), stockpiling (no structure), manure pack in buildings, and various other forms and combinations of manure storage's (Figure #4). The majority of sites monitored by the MPCA were concrete pits and earthen storage systems.

Figure #4 - Number of Field Samples versus Manure Storage Type



CP= concrete pit; **EB=** earthen basin; **AGT=** above ground tank; **SSS=**solid stacking slab; **DH=** daily haul; **StkPlg=** stockpiling; **MP=** manure pack

B. ANALYSIS AND DISCUSSION OF THE 1998 AMBIENT SCREENING DATA

1. Jerome Meter

A total of 435 individual hydrogen sulfide field data results were collected at 137 individual feedlot facilities around the state using the Jerome Meter. This field data was compared with animal units, distance from the emission source to the property boundary, animal type, manure storage method, style of livestock confinement, stability class, temperature, humidity and barometric pressure. The purpose of this comparison was to determine which factors effect or influence the concentration of hydrogen sulfide gases found in ambient feedlot air emissions. The data was collected using a Jerome Meter at or near the property boundary of each feedlot facility. Each data collection session represents a one-half hour average concentration based on 32 samples collected during a one-half hour period.

a. A Discussion of Site Selection

It has been estimated that there are currently 30,000 to 40,000 feedlot operations in the state of Minnesota. A total of 137 feedlot facilities were screened for the presence of hydrogen sulfide emissions. These sites were selected through several different processes, and are not a representative sample of state wide feedlot facilities. A total of 79 of these facilities were identified through the feedlot odor complaint process that the MPCA received from the public. A numeric computer modeling study of hydrogen sulfide and ammonia emissions was conducted by the MPCA in the Spring of 1998. The study included a total of 50 feedlot facilities (MPCA, 1998). The purpose of the computer modeling was to assist the MPCA in evaluating the cumulative impact of feedlot air emissions from an area densely populated with feedlot facilities.

Hydrogen sulfide field data collected at these 50 sites were used to better understand the computer model and assist in the interpretation of the modeled findings. The remaining eight facilities on the monitoring list were chosen as a control group based on the facility size (animal units), manure storage, and animal type.

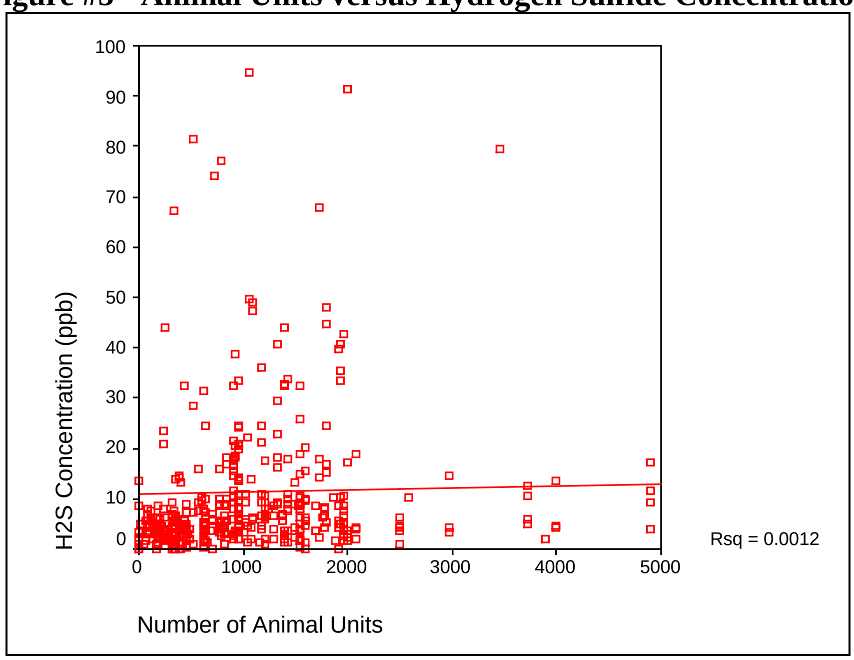
1) Hydrogen Sulfide and Animal Units

Recommendation #1a - Further research is necessary to identify which factors may affect the animal unit/hydrogen sulfide ambient air concentration relationship.

Hydrogen sulfide ambient air screening data was plotted along with the corresponding animal unit numbers of the feedlot facilities monitored during 1998. The animal unit numbers were derived from existing MPCA feedlot permits and Certificates of Compliance. The graphs do not take into account such factors as distance from the emission source to the sampling point, meteorological data, time of year and day, or specific farm management practice.

The data presented in Figure #5 illustrates the wide range of feedlots (expressed in animal units) that were monitored during the 1998 season. However, most of the data gathered reflected feedlot operations with less than 5,000 animal units. A majority of the operations monitored were under 2,000 animal units. Based on this compilation of data, no strong correlation between animal unit numbers and hydrogen sulfide concentrations exists. The facilities that had hydrogen sulfide concentrations greater than 30 parts per billion ranged from approximately 100 animal units to greater than 2,000 animal units. Further research is necessary to identify which factors may affect the animal unit/hydrogen sulfide concentration relationship.

Figure #5 - Animal Units versus Hydrogen Sulfide Concentration



2) Hydrogen Sulfide Emissions and Animal Type

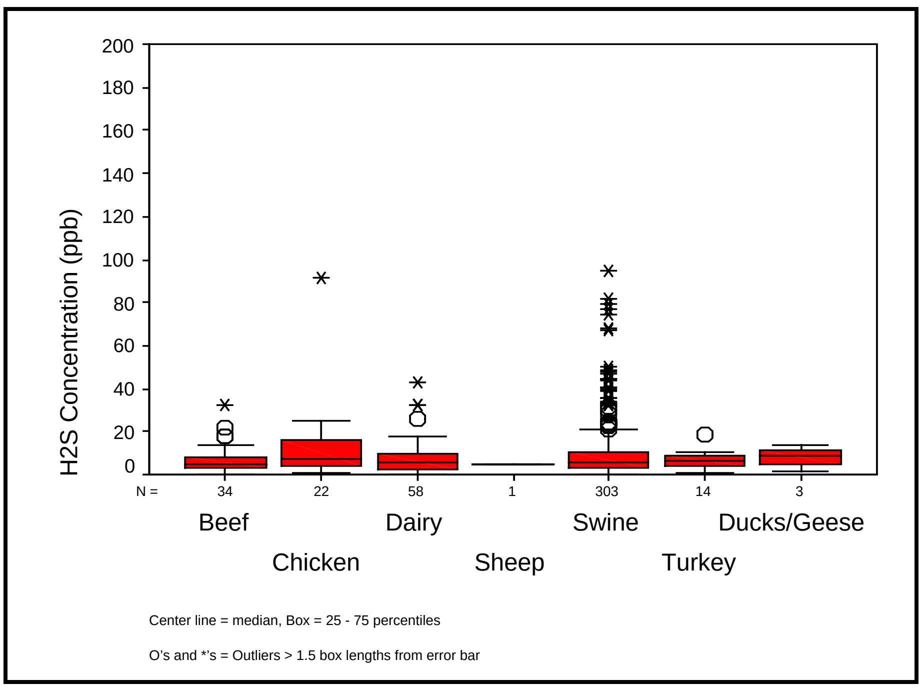
Recommendation #1b - Further research is necessary to determine if a relationship between hydrogen sulfide/odor emissions and animal species exists.

The hydrogen sulfide field screening data was plotted and compared with animal species type to determine if a relationship exists between livestock type and ambient hydrogen sulfide concentration. Based on the data collected in the field, the highest concentrations of hydrogen sulfide (greater than 30 ppb) are found at swine and dairy facilities. A one-half hour average greater than 30 ppb was also recorded at a chicken manure stockpiling facility and at a beef operation where stockpiling was used as the method of manure storage (see Figure #6).

It is important to understand the data bias of this compilation. Each data point graphed represents a single site visit. The site inspections were not random, therefore, this compilation is not representative of all confined animal feedlot operations. The site inspections were primarily the result of a complaint, or to a lesser extent, pre-selected through a numeric modeling study or the initial group compiled during the feedlot hydrogen sulfide program development phase. Swine facilities received the most complaints and therefore received the greatest amount of air monitoring. Therefore, a greater hydrogen sulfide field data set exists for the swine facilities than for any other livestock types. Furthermore, it does not reflect the manure management, manure storage method or the livestock housing type.

More field data is necessary to determine whether dairy, poultry, beef and turkey facilities present the same hydrogen sulfide findings that have been recorded at some swine facilities.

Figure #6 - Animal Type versus Hydrogen Sulfide Concentration



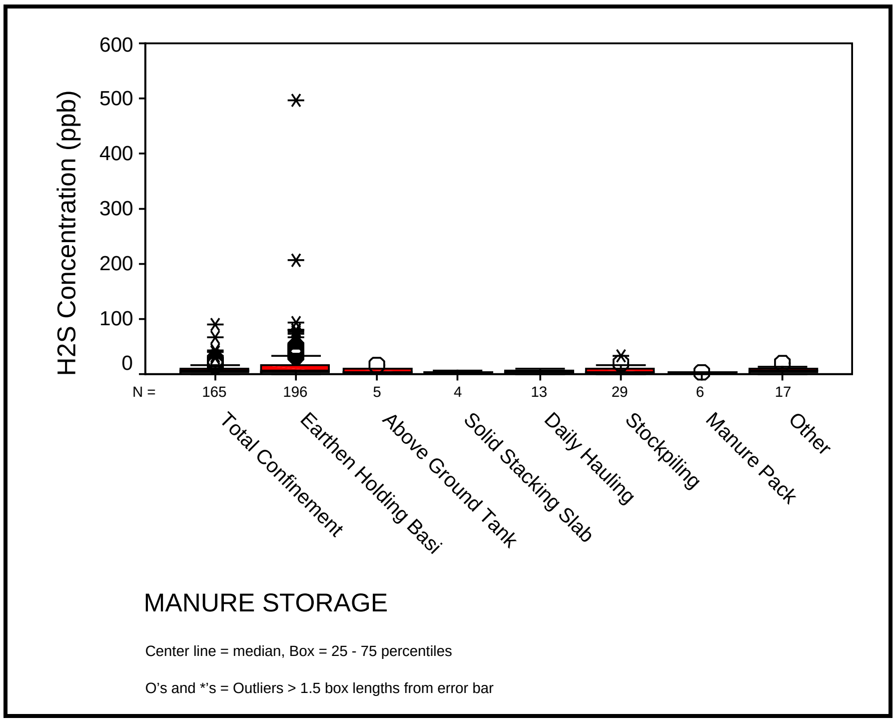
3) Hydrogen Sulfide and Manure Storage Method

Manure storage methods and management appear to be a factor in feedlot air emissions. Hydrogen sulfide field screening data was compared with manure storage methods to determine if a relationship exists between the concentration of hydrogen sulfide emissions and manure storage type (Figure #7). As previously discussed, data bias should be considered in interpreting this relationship.

The field screening data indicates that earthen storage systems have the greatest number of one-half hour hydrogen sulfide averages greater than 30 ppb. One reading taken at a facility using a concrete manure storage pit method was collected during a manure agitation and pumpout event. The facility has revised the procedure to include emission control measures that will reduce the concentrations of hydrogen sulfide below 30 ppb during agitation pumpout. A discussion of feedlot air quality during the agitation/pumpout process is discussed in section II.B.3. of this report.

The "other" manure storage method category includes stockpiling, daily haul, dry storage, etc.. The two highest readings in this category were recorded at facilities which employed stockpiling as their manure storage method.

Figure #7 - Manure Storage Type versus Hydrogen Sulfide Concentration

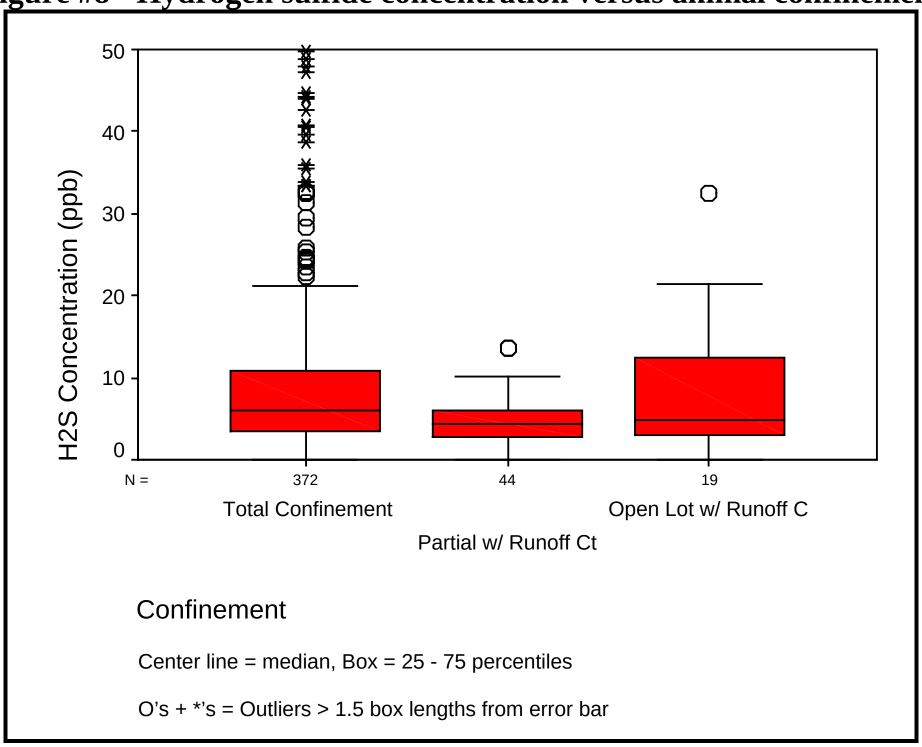


4) Hydrogen Sulfide and Animal Confinement Method

Recommendation #1c - Further research is necessary to identify which animal housing and ventilation styles affect hydrogen sulfide and odor emissions.

The relationship between livestock housing and feedlot air emissions has been documented by a number of researchers. Much of the research focuses on the ventilation rates and vent location as applied to total confinement operations through actual measurement or theoretical modeling (Van Ouwerkerk, 1993; Elzing et al., 1997). The MPCA attempted to define this relationship by comparing hydrogen sulfide ambient air data with livestock housing methods. The correlation as presented in figure #8 and does not appear to be very strong. This likely reflects a number of factors beyond the scope of the MPCA data collection efforts. The graph depicts that total confinement operations have the greatest number of hydrogen sulfide exceedances (greater than 30 ppb). However, this number is not indicative of the ventilation style (natural versus mechanical ventilation) or manure storage method (concrete pit or pull-plug/earthen storage). The partial confinement operations typically employ a stockpiling method or a daily scrap and haul practice. The greater than 30 ppb values recorded at the open lot facilities as indicated on the graph reflect the two readings collected at the beef and chicken stockpiles as previously discussed. Further field work is necessary to delineate the relationship between ambient air hydrogen sulfide concentrations and the various subsets of animal housing.

Figure #8 - Hydrogen sulfide concentration versus animal confinement



2. Continuous Air Monitoring (CAM) data

During the 1998 monitoring season, the MPCA conducted compliance-level continuous air monitoring (CAM) for hydrogen sulfide at several feedlot facilities around the state. The MPCA also collected CAM data for ammonia emissions at one feedlot facility in the state. The results of these efforts are represented as graphs located in appendices A through D of this report. The data was collected using either an MDA chemcassette ® or the TRS method. The results of the monitoring data for each facility are discussed below in conjunction with the specific preventative or corrective actions each facility employed to reduce hydrogen sulfide emissions below the ambient hydrogen sulfide standard.

a. Holden Farms - Pine Grove Facility

On April 9, 1998, the MPCA responded to a feedlot odor complaint regarding the Holden Farms - Pine Grove Facility in Section 21, Northfield Township of Rice County. At that time, screening data indicated that the facility had a potential to exceed the state ambient air hydrogen sulfide standards. Holden Farms responded by taking several actions to reduce hydrogen sulfide emissions at the facility. One of the preventative actions was the installation of a flexible pipe from the manure inlet (barn to first cell basin) and cross over pipe (between the first and second cell basins) that extends down into each basin. The purpose of this action was to deliver influent into each basin without cascading turbulence and minimizing influent contact with ambient air. The producer also adjusted swine rations to eliminate the use of copper sulfate in feed and will continue this practice.

Holden Farms, in cooperation with the University of Minnesota personnel, installed a straw cover to the first cell of the manure storage basin. On June 25, 1998, an MDA model SPM continuous air monitor was placed near the property line of the facility to determine compliance and the effectiveness of the preventative actions. Data was collected for 46 days during which the facility was in compliance with the state hydrogen sulfide standards. Daily episodes of elevated (<10 ppb) hydrogen sulfide concentrations were recorded between midnight and 1:00am. This data likely reflects the manure flushing process from the barns to the earthen manure storage structure (Appendix A).

b. ValAdCo Farm 2 Nursery/Finish Facility

ValAdCo operates the Farm 2 Nursery/Finish facility located in the southwest 1/4 of Section 27, Norfolk Township, Renville County, Minnesota. From November 1996 through November 1997, MPCA operated a TRS monitor approximately one mile west of the facility to assess exposure of surrounding neighbors to hydrogen sulfide emissions. The exposure study was jointly funded by the MPCA, the Minnesota Department of Health, the Minnesota Department of Agriculture and Renville County. The data collected at this site demonstrated a potential to exceed the state ambient air standard for hydrogen sulfide.

In April, 1998, the MPCA staff installed two CAMs at the southeast and northeast property boundary of the facility. The company initially implemented a preventative action using a biological additive to the waste storage system. However, violations of the ambient hydrogen sulfide standard were documented from April until August of 1998 (Appendix B). In September of 1998, the company installed a supported biomat using a geotextile material and straw. The concentrations of hydrogen sulfide were immediately reduced to levels well below state standard.

c. Neal Johnson Farm

On April 17, 1998, the Minnesota Pollution Control Agency (MPCA) responded to a feedlot odor complaint regarding the Neal Johnson Farm located in Section 15, Hector Township of Renville County. At that time, screening data indicated that the facility had a potential to exceed the state ambient hydrogen sulfide standard.

The producer responded by taking a number of preventative actions. One of the activities included planting a treeline to act as a wind break and elevate emissions. On June 19, 1998, the company installed a non-woven mat on the secondary basin cell in accordance with manufacturers recommendations and in consultation with the University of Minnesota. On July 7, 1998, a layer of straw approximately four inches thick was placed on the surface of the geotextile mat.

Continuous air monitoring at this facility was conducted at two locations. A total reduced sulfur monitor was located approximately one mile west of the manure storage basin for 32 days. During that time, no violation of the ambient hydrogen sulfide standard was recorded. The total reduced sulfur monitor was then moved near the Southwest corner of the property where monitoring continued for 90 additional days. Although, the 30 ppb standard was exceeded it did not result in a violation of state ambient standard. The elevated hydrogen sulfide reading coincides with agitation and pumping of the manure storage system. (See Appendix C1 for hydrogen sulfide data).

The ammonia data was collected using an MDA model 7100 continuous air monitor on loan from the Metropolitan Council Environmental Services. The monitor began collecting data at the facility property boundary on August 21, 1998. The data did not indicate an exceedance of the Minnesota Department of Health's proposed health risk value for ammonia (see Appendix C2 for ammonia data). Further discussion of the ammonia collection efforts is found in section II.C. of this document.

d. Christensen Farms - Swine Complex Facility

On May 17, 1998, the MPCA responded to a feedlot odor complaint regarding the Christensen Farms feedlot located in the southeast one-quarter of Section 21, Odin Township of Watonwan County. At that time, screening data indicated that the facility had a potential to exceed the ambient hydrogen sulfide standard.

The company responded by using a two-step waste treatment program which involves the addition of enzymes and bacillus to the waste storage system in an effort to reduce hydrogen sulfide emissions below the ambient hydrogen sulfide standard.

On August 20, 1998, the MPCA installed an MDA model SPM continuous air monitor near the property boundary of the facility to determine compliance with the ambient hydrogen sulfide standard. Continuous data was collected for 88 days and indicated that the facility was in compliance with the state standard (Appendix D).

3. Agitation and Pumpout

Several producers have indicated a concern that compliance with the hydrogen sulfide standards may be difficult during the manure storage agitation and pumpout process. In response to these concerns, the MPCA conducted air monitoring at select sites during the agitation and pumpout process. The MPCA contacted several feedlot facilities that have had an existing potential to exceed and asked for their assistance in collecting field data during agitation and pumpout. As a result, the MPCA collected 23 one-half hour hydrogen sulfide samples with a Jerome Meter during the agitation/pumpout process in the fall of 1998. Hydrogen sulfide levels found at the various facilities were similar to levels found during normal operating conditions (summer months) with some exceptions. The agitation and pumpout process caused elevated hydrogen sulfide levels at several earthen storage systems. Four of these facilities demonstrated a potential to exceed the ambient hydrogen sulfide standard during this process. It was also observed that facilities with enclosed concrete pits emitted elevated levels of hydrogen sulfide during brief pumpout periods lasting no more than 10 minutes at a time, resulting in a one-half hour average less than 30 ppb.

The MPCA has also collected hydrogen sulfide data during the agitation/pumpout process using CAM's. A discussion specific to each of these sites is included in the previous section. In general, the MPCA observed that in some circumstances, hydrogen sulfide levels did increase during the agitation and pumpout process. However, this phenomena may not occur at all operations. Further field work is necessary to determine if the agitation and pump out process is a problem relative to hydrogen sulfide.

C. AMMONIA DATA COLLECTION EFFORTS

Ammonia is a colorless gas with a very sharp odor. The odor is familiar to most people because ammonia is used in smelling salts, household cleaners, and window cleaning products. Ammonia (NH_3) is one of the nitrogen-bearing compounds present in odors associated with animal production systems (Kreis, 1978). The MPCA currently does not have any rule or law that regulates ammonia emissions, however, the Minnesota Department of Health is proposing a Health Risk Value (HRV) for NH_3.

Atmospheric ammonia emissions may also present a regional or even global environmental concern. Research has indicated that large parts of the European continent, nitrogen deposition to low nutrient ecosystems exceeds the threshold (the "critical load"), above which detrimental effects such as eutrophication and soil acidification are anticipated (Schultze et al., 1989; Posch et al., 1995). It has been estimated that between 50% and 70% of the NH_3 emissions in Europe are caused by animal production systems (Asman et al, 1995; ECETOC, 1994). In Minnesota, statewide total nitrogen (as ammonia) emissions from animal husbandry amounted to 104,508 tons per year (tpy). This compares with 70,187 tpy from mobile sources, 72,284 tpy from electric utilities, and 184,928 tpy as a total from all industrial sources (MPCA, 1998). However, it should also be noted that ammonia emissions on farms are influenced by various management factors which can vary from farm to farm as well as over time (Menzi and Katz, 1997).

Recommendation #1d - Further research is necessary to determine if atmospheric emissions of ammonia should be regulated in Minnesota.

The MPCA began addressing this issue through a preliminary data collecting effort. The MPCA began testing for NH_3 by collecting air samples at various livestock production facilities concurrently with the hydrogen sulfide monitoring. The purpose of this effort was to determine the presence and concentration of ammonia emissions from livestock production facilities. Two methods of air sampling were used to gather field data. One of the methods used was the Draeger Tube ® colorometric indicator. This is a portable hand held method used to take "grab samples" of air. Air is drawn through a glass collection tube with a hand-held pump. If ammonia is present in the air sample, it reacts with the substrate inside the tube, resulting in a color change. A calibrated scale on the outside of the glass tube corresponds to the change in color. The scale is read in parts per million (ppm). The lowest number on the scale of the glass tube is 2 ppm. Therefore, readings below this level must be interpreted by the user. The MPCA uses the Draeger Tube field data for qualitative purposes. It is merely an indication of the presence or absence of NH_3 at a feedlot facility.

A total of 56 ammonia samples were collected by the MPCA using the Draeger Tube ® method during the 1998 field season. All values collected appear to be less than 2 ppm.

The MPCA, in conjunction with the Metropolitan Council Environmental Services, placed an MDA Model 7100 CAM near the property line of the Neal Johnson Farm in Renville County, Minnesota to measure the concentration of NH_3 emissions in the ambient air. The NH_3 data collected at this facility does not indicate an exceedance of the proposed HRV. A copy of this data and related findings is found in Appendix C2.

The MPCA will continue to develop better ammonia measuring techniques and collect data to determine if further action is required to address ammonia emissions from feedlots.

Recommendation #2 - MPCA field staff need a more effective method of screening for ammonia emissions in the field.

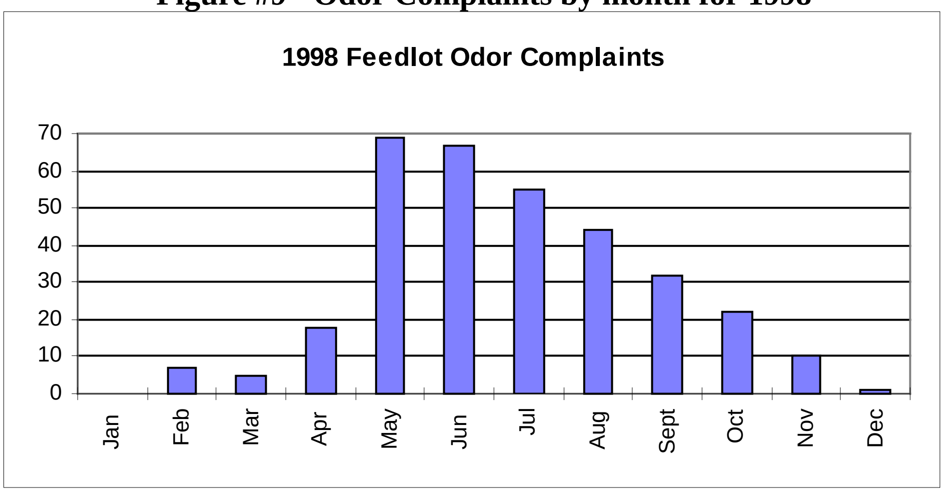
III. 1998 COMPLIANCE AND ENFORCEMENT ACTIVITIES

As specified by the legislature, the MPCA relies primarily on feedlot odor complaints to identify sites which may present a hydrogen sulfide compliance issue. Feedlot odor complaints are received by the MPCA throughout the year. When a complaint is called in to the MPCA, the complainant is encouraged to give his/her name and contact information to assist in follow up as well as identifying the location of the source. It is important to note that the identity of the complainant is confidential information as prescribed by Minnesota's Data Practices Act (Minn. Stat. § 13.44). Each site which receives a complaint is investigated in order to determine if a hydrogen sulfide compliance issue exists.

A. COMPLAINT DEMOGRAPHICS

Throughout 1998 there have been approximately 444 feedlot odor complaints logged by the MPCA. In the fall of 1997, the MPCA implemented a feedlot odor complaint recording system. During the remainder of 1997, a total of 82 complaints were recorded. In the Spring of 1998, the MPCA developed a feedlot odor complaint telephone line to assist in documenting odor complaints. In 1998, the MPCA documented a total of 352 complaints (Figure #9). The graph indicates an increase in the number of complaints during the summer months.

Figure #9 - Odor Complaints by month for 1998



Odor complaints have been logged in 42 different counties. Of the 42 counties which have facilities that received complaints, 15 of these counties have had one complaint. The other 26 counties are shown graphically with the number of complaints per county, and the number of distinct facilities specified (Table #2). Because complainants are not always able to give the name or precise location of the suspected source, there are also complaints for unknown facilities in each county. A total of 22 complaints indicated a general geographic location, but did not identify a feedlot facility name or clear location. Renville County shows the most complaints, 94, which indicated nine or more suspected facilities. Wright County has the next highest complaint rate with 43 complaints. All of the complaints in Wright County focus on two feedlot facilities.

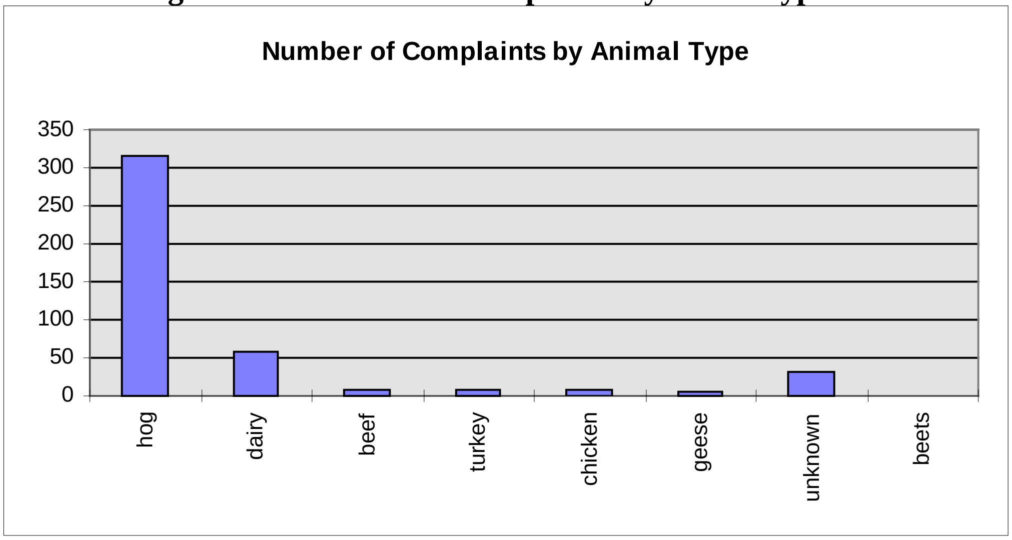
Complaints have been made about several animal types. As figure #10 below depicts, the great majority of complaints have identified hog operations as the primary odor generator.

A total of 194 complaints were logged by the MPCA regarding 18 of the 24 feedlot facilities that have demonstrated a potential to exceed the ambient hydrogen sulfide standard. The remaining six feedlot facilities were identified through other means and have not received any complaints to date.

Table #2
Number of Complaints by County and the related number of distinct facilities identified through complaint.

County	Total number of complaints	Number of distinct sites
Renville	118	9
Wright	42	2
Rice	40	4
Nicollet	39	1
Blue Earth	19	8
Martin	17	3
Watonwan	16	2
Waseca	15	6
Otter Tail	13	4
Roseau	12	1
Stearns	11	3
Yellow Medicine	8	2
Morrison	7	3
Benton	2	2
Lyon	5	4
Lincoln	4	1
Marshall	4	1
Redwood	4	1
Carver	3	2
Filmore	3	2
Jackson	2	2
Cottonwood	3	1
Mower	3	1
Norman	3	1
St. Louis	3	1
Isanti	2	1
Rock	2	1
Becker, Brown, Cass, Clay, Dodge, Goodhue, Freeborn, Hennepin, Hubbard, McLeod. LeSueur, Murray, Meeker, Moore, Sibley, and Stevens Counties have documented only one feedlot complaint with the MPCA.		

Figure #10 - Number of complaints by animal type



B. OVERVIEW OF THE HYDROGEN SULFIDE ENFORCEMENT RESPONSE PLAN

The MPCA has developed a hydrogen sulfide Enforcement Response Plan which it has used to guide the compliance and enforcement activities throughout 1998 (see Appendix E). When the MPCA Hydrogen Sulfide Initiative began in 1997, a list of feedlot facilities of various types and sizes throughout Minnesota was compiled by MPCA staff to be monitored as part of an initial study. Field screening data was collected at these sites in the fall of 1997 to assist in developing the screening protocol. These same facilities were included in the 1998 field screening efforts.

When the MPCA receives an odor complaint, the facility is added to the list of sites which MPCA staff or a County Feedlot officer will monitor. Upon each monitoring visit, MPCA or local government staff use the Jerome meter to measure the amount of ambient hydrogen sulfide found at the property boundary. The MPCA has set forth a monitoring protocol that requires the field scientist to determine where the highest odor plume concentration accessible downwind from the property boundary nearest the manure storage system is located for monitoring purposes (see Appendix F). The next step under the protocol requires the collection of a 30 minute sample of the feedlot air emissions at this location. The hydrogen sulfide field screening data is averaged and reviewed for quality assurance by MPCA air monitoring staff. Sites were monitored numerous times to evaluate the presence of hydrogen sulfide in the feedlot air emissions under various atmospheric conditions.

When the 30 minute sampling average is greater than 30 ppb, the MPCA considers the facility to have a potential to exceed the ambient hydrogen sulfide standard. The facility is contacted by the MPCA and notified of the monitoring results. When a site demonstrates it has a potential to exceed, the facility owners/operators are requested to meet with the MPCA. The purpose of the meeting is to discuss the situation at the facility, the ambient hydrogen sulfide standard, what measures could be taken to reduce hydrogen sulfide emissions and maintain compliance. The facility is requested to voluntarily enter into a Memorandum of Understanding (MOU), which is a public document that details the steps the facility will take in order to reduce the hydrogen sulfide emissions which are produced by the feedlot facility and manure storage system.

1. Facility Response to Documented Potentials to Exceed

Throughout 1998 monitoring season, 24 feedlot facilities that have demonstrated a potential to exceed the ambient hydrogen sulfide standard (See Appendix G). An actual violation of the ambient hydrogen sulfide standard was not documented because the potential to exceed in these circumstances was based on the Jerome Meter screening data rather than the continuous air monitors approved by the MPCA to determine compliance. An MOU was used to address the "potential to exceed" condition at 19 of the 24 feedlot facilities. The MOU has a monitoring provision which requires Jerome Meter screening in addition to the preventative actions. Each feedlot facility with a demonstrated potential to exceed must conduct Jerome Meter screening, following MPCA monitoring protocol as described in Appendix F, on at least eight occasions of differing meteorological and management conditions for the purpose of determining the effectiveness of the preventative actions. The data must then be submitted to the MPCA within 5 days of collection. The MOU is signed by producer, and the MPCA. The MOU is not an enforceable document. It serves to clarify what actions the producer intends to take to reduce hydrogen sulfide emissions at their facility. By entering into the MOU, the MPCA is not endorsing any preventative actions. It is the responsibility of the producer to choose a preventative action that it has reason to believe will be effective in the mitigation of hydrogen sulfide emissions. Some MOU's include a narrative by the producer that illustrates the operation and history of the facility.

The MPCA has also used feedlot permits to address hydrogen sulfide emissions. The feedlot permits of livestock operations that had demonstrated a potential to exceed have been modified to require the permitee to reduce hydrogen sulfide emissions at the facility. By using the feedlot permit, preventative action and monitoring provisions become enforceable conditions.

The MPCA has authority to issue an Administrative Order (AO) to require a facility to demonstrate compliance with the hydrogen sulfide standard. An AO may require a feedlot operator to undertake corrective actions and/or install a continuous air monitor at the owner's expense.

The MPCA prioritizes sites which has shown a potential to exceed to determine which will receive continuous air monitor to determine compliance status and the effectiveness of the preventative actions. The length of time that an MPCA continuous air monitor is located at a site is dependent on the emission levels recorded by the continuous air monitor at the site, as well as agency resources and priorities.

2. Enforcement Activities as a Result of Documented Violations

If a violation of the state hydrogen sulfide ambient air standard is recorded with a CAM, enforcement action is taken. This may include requirements for corrective actions, a monetary penalty or a combination of the two. Each enforcement action is considered on a case by case basis to determine the type of enforcement tool to be used, and if applicable, the amount of a monetary penalty.

The MPCA has taken enforcement actions related to feedlot air quality. One feedlot facility in the state violated the ambient hydrogen sulfide standard. In this situation, multiple exceedances of the state standard were documented with an MPCA approved method for continuous air monitoring. The exceedances of the standard were recorded throughout the spring and summer of 1998. The MPCA used an enforcement tool known as a stipulation agreement to resolve this issue. A stipulation agreement is a legally binding agreement between the MPCA and the company and includes various corrective actions, a timetable to complete these activities, a monetary penalty for current violations and stipulated penalties for violation of conditions in the agreement. In this situation, the company was required to cover the waste storage system with a biomat, and pay a civil penalty for the ambient hydrogen sulfide standard exceedances. The company has also undertaken two supplemental environmental projects that will benefit the environment and further feedlot air quality research. The company has volunteered to fund a feedlot air quality research project and also to cover two of their facilities which have not demonstrated a potential to exceed the ambient hydrogen sulfide standard. Continuous air monitoring is also a requirement of the agreement to demonstrate continuing compliance.

The MPCA has also taken two enforcement actions related to reporting violations of mitigation and monitoring measures that have been incorporated into MPCA feedlot permits. The MPCA used an enforcement tool known as a Notice of Violation (NOV) to resolve these issues. An NOV has corrective measures to bring a facility into compliance with the permit condition or rule and is not used to levy a civil penalty.

IV. FEEDLOT AIR EMISSION CONTROL TECHNOLOGIES

The mitigation and control of feedlot air emissions is an emerging science. Several technologies are currently available to reduce odors, unfortunately, economics often prohibit such technologies from being implemented (Jacobson et al, 1998). Furthermore, the uncertain effectiveness of some technologies along with long-term management are major factors in the decision producers face when deciding which mitigation method to implement. The following section describes some of the mitigation technologies that MPCA staff have observed or reviewed. Some of these mitigation methods have been employed by facilities that have demonstrated a potential to exceed the state ambient hydrogen sulfide standard (Appendix G). The University of Minnesota Biosystems and Agricultural Engineering Department has evaluated some mitigation technologies for feedlot odor control. A copy of this evaluation is found in Appendix H.

Recommendation #3 - The MPCA, Counties and producers need research into the effectiveness, management and cost of mitigation methods for hydrogen sulfide and odor.

A. ANIMAL WASTE SUPPLEMENTATION

Various researchers have investigated the amendment of animal feed and waste streams with chemical and bacteria products in an effort to reduce or eliminate odorous emissions. Typically, these additives are categorized by the mechanism of action (Swine Odor Task Force, 1998). For the purposes of this discussion, we have categorized them as biological or chemical additives. Some of this technology has been marketed to the livestock production industry. The MPCA has observed the results of the use of some of these products and found varying levels of hydrogen sulfide and odor emission reduction. The following is a review of the findings that MPCA staff have observed with various animal waste supplementation products.

1. Biological Additives

There are numerous manure biological waste supplements on the market. Vendors typically claim these formulations are designed to enhance bacteria growth, including sulfur reducing bacteria. One claim is that the correct balance of bacteria will allow sulfur reducing bacteria to form non-reactive elemental sulfur, which will remain in the organisms, presumably even after they die and settle to the bottom. Most of these products are applied directly into the manure collection area and must be added frequently to allow selected bacteria to predominate (Sweeten, 1991). However, the odor, ammonia and hydrogen sulfide reduction achieved using these products appears to be questionable. Supplemental microorganisms may not readily adapt to the natural conditions in manure handling systems and are often susceptible to competition from the naturally occurring indigenous microbial populations (Miner, 1995). MPCA experience with these products is very limited, however, we have not encountered any continuous air monitoring data that would support any hydrogen sulfide emission reduction claim.

In 1998, MPCA staff worked closely with a company that tested a biological formulation for four months in a barn and manure storage lagoon. Initially, the vendor indicated that improvements in the wastewater would be realized within a few weeks and reductions in emissions should be expected within a month or two. The MPCA maintained continuous air monitors at this site during most of the product use. Although, at times, there appeared to be some observable changes in wastewater quality, ambient air quality levels remained above the hydrogen sulfide standard and were quite variable. Non-compliance continued for several months and the company was unsuccessful in making improvements to the hydrogen sulfide ambient air quality using this product. The company opted for a biomat cover that proved successful at reducing hydrogen sulfide emissions to acceptable levels during the remainder of 1998.

Although we have not observed biological formulations that have immediate effects on non-compliance with the hydrogen sulfide ambient standard, they may have other beneficial uses such as improved manure management. Claims such as better solids dispersion appear to be true, and there may well be other benefits to their use. Some studies claim reduction in barn odors (Zhu et al., 1996). A Minnesota study reported some reduction in ammonia emissions using certain biological additives, however, odor threshold results were variable and most products tested had only a slight effect on odor reduction (Johnson, 1997). Their effective use as a hydrogen sulfide emission mitigation technology has not been observed by MPCA staff.

Another concern is the long-term effects of land application with biologically amended animal waste. MPCA staff have not encountered any literature that would indicate if such a concern is warranted.

2. Chemical Additives

There are numerous chemical additives which are commercially available to modify the chemistry of feedlot manure wastewater. These additives include masking agents and counteractants. The MPCA has not observed whether these methods may be effective at reducing hydrogen sulfide emissions or odor and has not conducted any compliance level hydrogen sulfide monitoring at any feedlots where these products have been tested.

Anaerobic conditions usually exist in earthen and concrete manure storage systems. These conditions cause the generation of acids that lower the pH and convert the sulfates present in the manure wastewater to hydrogen sulfide. Chemical pH adjusters such as lime can be added to a barn pit or lagoon to raise the pH in efforts to reduce hydrogen sulfide emissions. One problem which occurs in these situations is that raising the pH favors production and release of ammoniated compounds. Thus it is possible to reduce hydrogen sulfide and consequently, increase ammonia emissions. An increase in ammonia emissions will likely increase the incidence of odor.

Lowering pH can also have some positive affect on air emissions. Ferrous chloride is a chemical which if added to a lagoon water which would act as a chemical precipitant reducing ions soluble in the wastewater. Ferrous chloride was added to a feedlot lagoon in Minnesota in 1996 in an attempt to reduce odor emissions following spring turnover. This was a “one-time” batch addition of ferrous chloride that was intended to stop the odors that were being generated at that time. It was reported by one feedlot operator to have reduced odors; however, there was a concern that changing the chemistry in the lagoon to a more acidic environment would have long term negative effects on biological conditions in the basin and thus increase air emissions.

Several years ago, masking perfumes were tried in Minnesota at several feedlot facilities. Although they were effective at masking the emissions, residents complained that the odor of the perfume was also offensive. The use of masking agents actually increased alarm over air quality because residents had no means of knowing when the emissions of noxious gases were occurring due to the masking agent.

The University of Minnesota is experimenting with a dust suppressant product to control barn odors (Jacobson, 1999). A vegetable based oil has been used in the initial trials. Based on preliminary research, this application might be useful in barns with side curtains where barn floor dust and air is not forced into a common ventilation system where treatment might otherwise occur. However, an additional finding indicated that extra labor was needed to clean the oil treatment room after each group of swine were moved out of the building (Jacobson, 1999). So far, application has been by hand held applicator, relying on the producer to apply the oil. The research also indicates that a regular application might be more reliable using an automated system. Further evaluation of an automated oil treatment system is planned for 1999.

The University of Minnesota is considering doing an evaluation of chemicals that may be useful to temporarily reduce emissions during critical periods such as agitation and draw-down of manure storage facilities. There is concern that the chemical additives could shorten the useful lifespan of some manure storage structures. Another concern that is common with the biological amendment is the long-term environmental effects of land applying chemically enhanced animal waste on the environment. Further research is necessary to determine if this concern is warranted.

B. BIOFILTERS AND COVERS

A biofilter is composed of media such as soil, peat, compost, straw or similar biomass where microorganisms reside in thin biofilm layers of moisture around the media particles. A biomat cover employs a similar process at the surface of a liquid manure storage system. The compounds in the air stream are adsorbed or absorbed into the biofilm layers where a microbial community resides and oxidizes them to less harmful products such as water, carbon dioxide and inorganic salts (Williams and Miller, 1992). Biofiltration technology has been used for well over 20 years as a method for reducing odors at composting operations, solid waste facilities and animal rendering plants (Williams and Miller, 1992).

The following discussion reviews the MPCA staff observations of biofilters and covers around the state.

1. Biofilter Technology

Biofilters employ the use of a mixture of earth, compost, straw and woodchips as a filter media for barn ventilation gases. The technology collects barn vent fan gases and directs them to the filter media for emissions reduction. Developed in Europe over the last decade, the University of Minnesota has conducted some tests and full-scale studies of this technology at the Richard Nicolai farm near Hector, Minnesota (Zeisig and Munchen, 1987; Noren, 1985; Nicolai and Janni, 1998a). Currently, this is the only operational production scale biofilter at a feedlot facility to be used in the state of Minnesota and possibly in the United States. Research has also been conducted on four small biofilters in the state to evaluate performance treating pit fan exhaust air from deep-pitted swine nursery (Nicolai and Janni, 1998b).

These studies indicate an average overall reduction in odor and hydrogen sulfide of approximately 80 %. Ammonia reduction was a little over 50 %. MPCA staff visited the Nicolai farm in the fall of 1998. Very little if any odor was noted at the site. The full scale barn study was conducted over a ten month period. The spent biofilter material can be land applied using conventional methods.

Keeping the media wet is important in maintaining a healthy biological condition in the biofilter media. This has been accomplished this by using well placed residential lawn and garden sprinklers. Research indicates that natural dust and particle settling will tighten the biofilter media and reduce porosity which leads to a reduction in air flow (Nicolai and Janni, 1997; 1998a; 1998b; 1998c). This will likely translate to a reduction in odor and hydrogen sulfide mitigation. Pressure drop is monitored to evaluate the air flow. A roto-tiller was used to unplug and aerate tightening biofilter media. Rodents have also been a problem but can be controlled by conventional means.

2. Cover Technology

There are several different covering methods used at feedlot facilities in the state to reduce emissions below the state ambient hydrogen sulfide standard. These include supported and unsupported permeable and impermeable covers. A biomat is a type of cover which uses biomass that is either supported or unsupported on the surface of the waste storage system. Biomats are similar to biofilters in that the same process of mitigation reduces the concentration of emissions from the source. Several feedlots in the state have used biomat technology to reduce air emissions from earthen manure storage facilities. These have included the use of floating straw on lagoon or solid separator system surfaces, geotextile fabric floating on lagoon surfaces or a combination of straw and geotextile. Generally, 8 to 12 inches of wheat or barley straw is placed on the basin surface which acts as a biofilter to reduce emissions. Several feedlots in the state participated in a University of Minnesota study that evaluated the various styles of biomats. The results indicate a substantial reduction of odor and hydrogen sulfide (Clanton, 1997; Jacobson, 1998). This effect can be obtained by the use of either the unsupported straw mat or the geotextile fabric material. The Prairie Agricultural Machinery Institute (PAMI) has conducted research and reports similar results with various straw covers (PAMI, 1993). MPCA monitoring data contained in Appendices A, B, and C indicate a reduction in peak hydrogen sulfide values and compliance with the ambient air standard when the covers are properly maintained.

PAMI (1993), indicates a preference for barley straw due to its reportedly favorable buoyancy characteristics. The University of Minnesota reports similar results with either wheat or barley straw. With the use of either material it is important to inspect the straw cover regularly and apply new straw to areas that have opened up due to shifting or sinking of the biomat. In their research, the University of Minnesota observed one facility where the straw mat did not remain floating. One concern is the longevity of the unsupported straw biomats, and if it will remain intact or sink over the Minnesota winter. Sinking has been observed in some instances where straw covers have been employed in colder climates such as Canada (PAMI, 1993).

Application of straw is accomplished using a chopper/blower. Several companies have developed equipment for this type of application. It is reported that straw can be blown approximately 80 feet in calm conditions and perhaps 150 feet with assistance from the wind. Application distance and distribution can be improved by floating masses of straw with the wind on the lagoons surface. However, reapplication on areas where straw has become submerged can not always be accomplished by this method on larger lagoons. Considering the typical dimensions of an earthen storage system, reapplication of straw would in most cases be limited to basins that are less than two acres (Jacobson, 1998).

Some producers have indicated a reluctance to try straw for fear that it will plug washwater return lines or manure pump-out equipment. PAMI has reported that in some cases slight modifications of equipment may be necessary. The University of Minnesota and PAMI have reported that these problems can be overcome relatively easily with the use of chopping blades fitted to the manure pumps (Jacobson, 1999a; PAMI, 1993).

Geotextile, a buoyant, permeable cover, has been demonstrated to be a suitable method for odor and hydrogen sulfide reduction. In Minnesota, facilities using geotextile have utilized an eight ounce material. Geotextile is particularly effective for larger earthen storage systems where straw application would be limited. The University of Minnesota and the MPCA collected data from several facilities employing geotextile or a combination of geotextile and approximately 4 inches of straw. In all cases where the cover was applied the reduction in odor and hydrogen sulfide has been immediate and dramatic.

Since geotextile fabric has been used during a single season, there is field data on the life expectancy of the product in this application. One Minnesota consultant report estimates, based on ultraviolet degradation of the geotextile, that the cover may last three to six years (Baumgartner, 1998). The use of a straw layer may improve the life expectancy of the cover by blocking the ultraviolet light as well as enhance the biofiltration effect. Costs per piglet have been reported as low as about thirty-five cents. A more complete economic evaluation of manure storage covers has been compiled for the Minnesota Department of Agriculture (Jacobson, 1998b).

Pump-out of the geotextile has been accomplished by rolling back a portion of the cover and drawing down the lagoon. Appendix C1 illustrates the increase in hydrogen sulfide emissions occurring at one facility during this period.

Other floatable covers and related support systems that have been reported include, styro-foam board material, sealed bleach bottles and burlap. These support systems are then covered with straw to achieve the biofiltration effect. Currently, the MPCA does not have any emission data or management results on the effectiveness of these biomat support systems.

C. Electrical Conductivity and Non-Thermal Plasma Treatment

Modification of lagoon chemistry through the use of electrical current is a technology which is being considered by several producers and researchers. The MPCA has received information from two companies employing this concept. One process uses electrified aluminum rods in the manure storage lagoon in an attempt to change the lagoon chemistry and reduce emissions.

A Minnesota based company is utilizing a high amperage, low voltage carrying stainless steel electrode. The electrode is deployed in the wet well prior to manure storage. The company reports that the process reduces hydrogen sulfide emissions, reduces ammonia nitrogen losses and stimulates algae growth within the waste storage system. The company is presently using the device at a feedlot facility located in Nicollet County. The feedlot facility is a swine production unit with a two stage earthen storage system.

MPCA staff have not reviewed any chemistry data which would determine if the electrified stainless steel electrode has altered the composition of the system. However, the site has been visited on numerous occasions by MPCA staff and Jerome Meter screening data has been less than 30 ppb near the property boundary. MPCA staff have also been at this facility during agitation and pump out with similar screening data values below 30ppb.

Recent research has been conducted on the use of non-thermal plasma generator to reduce gaseous emissions from feedlots (Ruan et al., 1997). Non-thermal plasma (NTP) is created by discharging electrical energy into gases (Rosocha, 1996). The process requires a gas collection system to convey the gases to the NTP generator for treatment. The research was conducted at a Minnesota swine production facility where a plastic cover was employed on the lagoon to capture emitted gases. Gases collected under the cover were diverted to the NTP generator where the emissions were converted to non-odorous and non-toxic compounds.

Several non-thermal plasma systems, including pulse corona, silent discharge, surface discharge, and packed-bed reactors were developed and used for treatment of pure hydrogen sulfide and ammonia gases, and gaseous samples collected from livestock facilities. The performance of these systems with different gas flow rates, gas compositions, humidity levels, pulse frequencies, and voltages were evaluated. Production of carbon monoxide and ozone, as byproducts of the reaction, were also observed. Total decomposition of hydrogen sulfide and ammonia has been achieved under optimum conditions. Odor intensity of the gaseous samples collected from livestock facilities was greatly reduced based on the University of Minnesota human test panel results (Ruan et al., 1997). NTP appears to be a promising technology for treating dilute mixtures of odorous gases. However, a current financial limitation appears to be the gas capture system needed to collect the gas mixture.

D. Aeration And Other Technologies

In its broadest sense, aeration is a process by which the area of contact between water and air is increased, either by natural methods or by mechanical devices. This discussion specifically focuses on mechanical devices or procedures for aeration.

In this limited sense, aeration clearly defines itself as a method of treatment rather than merely a modification of natural conditions at the source of supply. The general idea behind aeration is to bring the water or waste in contact with the air. Either the water or waste may be discharged into free air or the air may be forced into a body of waste. Apparatus used includes: low cascades, multiple jet fountains throwing water to considerable heights, multitudinous spray nozzles discharging not far above the surface of a reservoir or waste storage system, superimposed trays or shelves, submerged perforated pipes, and porous tubes and plates.

The MPCA has observed one feedlot in Minnesota that has used an experimental passive aeration system. The results of this project shall be published in the spring of 1999 (Gantzer, 1999). Generally, complete stabilization of livestock manure by aerobic treatment is normally not economically justifiable (Westerman and Zhang, 1997). Using a lower rate of aeration reduces the release of volatile acids and other odorous gases and compounds as well as allowing some oxidation to less odorous compounds (Westerman and Zhang, 1997).

1. Thin Layer Aeration

Conventional aeration technologies like those employed for municipal and industrial wastes can be used to treat feedlot manure. These technologies not only reduce odor and hydrogen sulfide but are primarily intended to reduce organic and ammonia nitrogen levels in the wastewater. These technologies are designed to aerate the entire waste resulting in a high level of energy consumption. This high level of energy consumption means that the cost of treatment for animal unit is also high due to electrical consumption. These high costs have led some companies to consider lower energy aeration technologies which target hydrogen sulfide emissions generated in existing agricultural earthen manure storage systems.

MPCA staff are aware of several systems designed to target hydrogen sulfide by creating a thin layer of air at the surface of the manure waste storage lagoon. These systems are in varying degrees of development. The aeration for these systems is more passive than traditional technologies. Air from the generator rises gently to the surface of the lagoon creating a layer of air at the surface. Conceptually, hydrogen sulfide formed in the anaerobic zone of the pond rises through the thin layer of oxygen generated by the aeration system. The hydrogen sulfide is oxidized to sulfate in this layer, reducing the odor generated by hydrogen sulfide.

2. Anaerobic Sequencing Batch Reactor

This technology replaces the multi reactor systems in a conventional aeration process with a single reactor. The typical processes of aeration, sedimentation and clarification which are normally carried out simultaneously in several tanks, are carried out in a single tank in a sequential fashion. The intermittent nature of flushing the wastes gives this type of system some benefit over conventional treatment, which requires continuously flowing wastewater. Additionally, the capital costs for this system are expected to be lower than for a conventional plant. The MPCA is not aware of any Minnesota feedlots currently using this technology. Research has been conducted in Canada regarding temperature control and digestion (Masse et al., 1997). This may greatly affect the overall cost of processing the waste. Cost estimate and technical information can be obtained by contacting the University of Minnesota Department of Biological and Agricultural Engineering.

3. Anaerobic Digestion

Anaerobic digestion, the biological treatment of waste in the absence of oxygen, is often used to treat high strength wastewater from industrial sources. The anaerobic digester has the advantage over conventional anaerobic lagoons which are uncontrolled and can cause noxious odors. In an anaerobic digester, the biological processes are enhanced and controlled and the biogases, such as methane carbon dioxide and hydrogen sulfide are collected. The wastewater which results is stable and rich in nutrients. The biogases can be used as an energy source for heating or to drive generators as an intermittent electrical power source. The energy source can be used to offset start up capital and operating costs. Currently, there are 28 digesters in operation at feedlot facilities in the United States with 10 more either planned or under construction (Lusk, 1998).

This process has several benefits and limitations. The manure can be used to generate electricity and still be used as a nutrient source. however, design, economics, equipment maintenance costs and erratic biogas production as well as educating and training costs have limited the use of this technology.

E. Crust Formation on Earthen Manure Storage Structures

Typically, dairy operators using an earthen storage system have observed the formation of a crust on the surface of the system. Crusts have also been observed forming on the surface of some swine and poultry earthen manure storage systems. It has also been observed that odors were reduced by approximately 60 to 85% after the formation of a crust (Mannebeck, 1985; Jacobs, 1994). One factor that appears to influence the odor mitigation effectiveness of a crust is the moisture content of the crust media. A major benefit of a naturally forming crust is that it is virtually cost-free.

Several dairy facilities in the state that have demonstrated a potential to exceed the state ambient hydrogen sulfide standard have indicated that they would facilitate and manage a crust on the surface of their system in an effort to reduce hydrogen sulfide emissions below the standard. While a crust does appear to reduce odor, it is uncertain whether it can be used to maintain compliance with the ambient hydrogen sulfide standard throughout the year.

The use of a crust to control odor and keep a facility in compliance with the ambient hydrogen sulfide standard appears to have great promise. However, research is needed to identify the factors that influence crust formation and best management practices to maintain the crust throughout the year. This will greatly assist the MPCA in permitting and environmental review by demonstrating the effectiveness of a crust to control air emissions.

F. Fuel Cell Technology

The MPCA is involved in a proposal to study the feasibility of collecting gasses from feedlot waste, in order to fuel a fuel cell. The objective of this project is to determine the feasibility of using fuel cell technology to convert biogas generated at a feedlot to produce electricity. The biogas recovery technology has been used since the 1980s. The systems currently operating are using internal combustion engines to produce electricity. Unfortunately, the current system also produces nitrogen oxides(NOx), sulfur dioxide(SOx) and carbon monoxide(CO) in the combustion process.

There are basically two types of animal manure digesters operating in the United States. One systems flushes manure using a combination of fresh and recycled water into a large lagoon storage and treatment system. Biogas is produced in covered lagoons as the manure is digested by naturally occurring bacteria. The biogas is trapped under a cover, collected in perforated pipes and transmitted to an engine generator.

A second type which is more adapted to colder regions uses a tightly sealed, insulated, heated tank as a reactor. Manure is collected from the animal housing unit and pumped into the insulated reactor at least once a day. An equal amount of effluent flows out of the reactor to a storage structure. Biogas is collected below the cover of the reactor and some is used to heat the reactor. The excess biogas is utilized in an internal combustion engine which drives a generator connected to the electric power distribution grid. Energy either flows to other uses on site or is purchased by the local electric distributor.

The environmental benefits to this system are significant. The biogas is being used as a renewable source of energy, often enough to supply most, if not all, the operational electrical needs of the farm. The system reduces the amount of hydrogen sulfide, ammonia, methane and odors otherwise released to the air.

Use of a fuel cell will reduce the negative environmental impacts. The fuel cell converts energy directly, without combustion, by combining hydrogen and oxygen electrochemically to produce water , electricity and heat. Although the fuel cell technology has been used in similar processes, such as landfills, it is unclear whether the technology will be compatible with biogas from a feedlot.

The grant request will fund a feasibility study to determine if the technology could be practically implemented. It will also determine the degree of benefit to all affected parties: the community, environmental agencies and power companies. Depending on the biogas supply, the 200 kW fuel cell is capable of producing enough electricity to supply 100 to 150 homes with electricity.

This grant will be used to hire a consultant to perform a feasibility study. The study should not take more than six months to prepare and will determine: 1) if this type of technology can be implemented, 2) what parameters have to be met in order to implement a pilot study and 3) a cost/benefit analysis as well as a projected environmental benefit analysis.

V. THE ROLE OF FEEDLOT AIR QUALITY IN ENVIRONMENTAL REVIEW AND FEEDLOT PERMITTING

A. ENVIRONMENTAL ASSESSMENT AND REVIEW

The purpose of environmental review is to determine if a proposed facility will have an adverse effect on the environment. With respect to feedlots with proposed total confinement facilities, an Environmental Assessment Worksheet (EAW) is required if a new livestock facility is constructed with 2,000 animal units or more, or if 2,000 or more animal units are added to an existing livestock facility. For partial confinement facilities, an EAW is required if a new livestock facility is constructed with 1,000 animal units or more, or if 1,000 or more animal units are added to an existing livestock facility. An EAW may also be prepared in response to a petition signed by 25 citizens. The petition must address "real" environmental issues. This is known as a petitioned EAW. The third way an EAW may be conducted is at the discretion of a government agency with permitting authority over the feedlot. This is known as a discretionary EAW.

The MPCA is the responsible governmental unit for all EAWs prepared for feedlots, and prepares the EAW with the assistance of the project proposer.

During the EAW process for feedlots, air quality has increasingly been an issue. Further, many of the public comments collected during the EAW process have indicated that odor has been a paramount issue. The MPCA may not issue a permit if the permittee will not comply with all applicable state and federal pollution control statutes and rules administered by the MPCA. (Minn.R. 7001.0140 subp. 2.A). In addition, a facility cannot be permitted if the facility endangers human health and the environment, if the danger cannot be removed by modification of the conditions of the permit. (Minn. R. 7001.0140 Subp. 2D.). The MPCA considers if a proposed feedlot facility has a potential to exceed the ambient hydrogen sulfide standard and proposed HRV's for ammonia and hydrogen sulfide. The following discussion is a summary of the feedlot air quality issues the EAW review process.

1. Computer Modeling

Computer models have been used to predict the concentration of various emissions and the nature of their dispersion by various governmental entities, universities and industries for several decades. Modeling has proven to be an effective tool to evaluate and predict compliance with various state and federal air quality standards. The application of computer modeling to feedlot facilities is a fairly new idea.

The MPCA is currently reviewing various computer models to determine which model is a better predictive tool for feedlot emissions. At this time, the MPCA has conducted air quality modeling for various proposed and existing feedlot facilities in the state. The computer modeling is directed at determining whether a feedlot facility will be in compliance with the state hydrogen sulfide ambient air standards and whether the facility's emissions will exceed the proposed ammonia and hydrogen sulfide HRVs. If the computer model indicates that the facility as proposed will exceed the ambient standards or the HRVs, the producer may have to modify the proposal.

2. Cumulative Impact Studies

In 1998, an air dispersion modeling study was conducted by the MPCA for a nine township area in west-central Minnesota (MPCA, 1998). The study was conducted to evaluate the potential for emissions of odorous gases from animal feedlots located in close proximity to one another that may result in heightened emission concentrations. This phenomena is known as a "Cumulative Impact". The results of this investigation indicated that several facilities in the study area had "modeled" a potential to exceed the ambient hydrogen sulfide standard and the proposed ammonia HRV.

Based on this MPCA investigation, a Minnesota Court has directed the MPCA to evaluate the effect of cumulative air emissions from existing feedlots surrounding a proposed feedlot project as part of an environmental impact statement. *Pope County Mothers and Others, et al. v. Minnesota Pollution Control Agency* Court File No. CX-98-2308 (Minn. Ct. App.). This precedent will also affect future EAW review of proposed feedlot facilities. The MPCA Interim guidance will address the cumulative impact issue during the EAW and permitting process.

B. FEEDLOT PERMITTING

The MPCA is responsible for issuing feedlot permits in the state. This authority is delegated by the MPCA to several counties in the state. The feedlot air quality issue brings new challenges to the feedlot permitting process. The following is a summary of these challenges and the MPCA response to these issues.

1. Air Monitoring and Preventative Actions

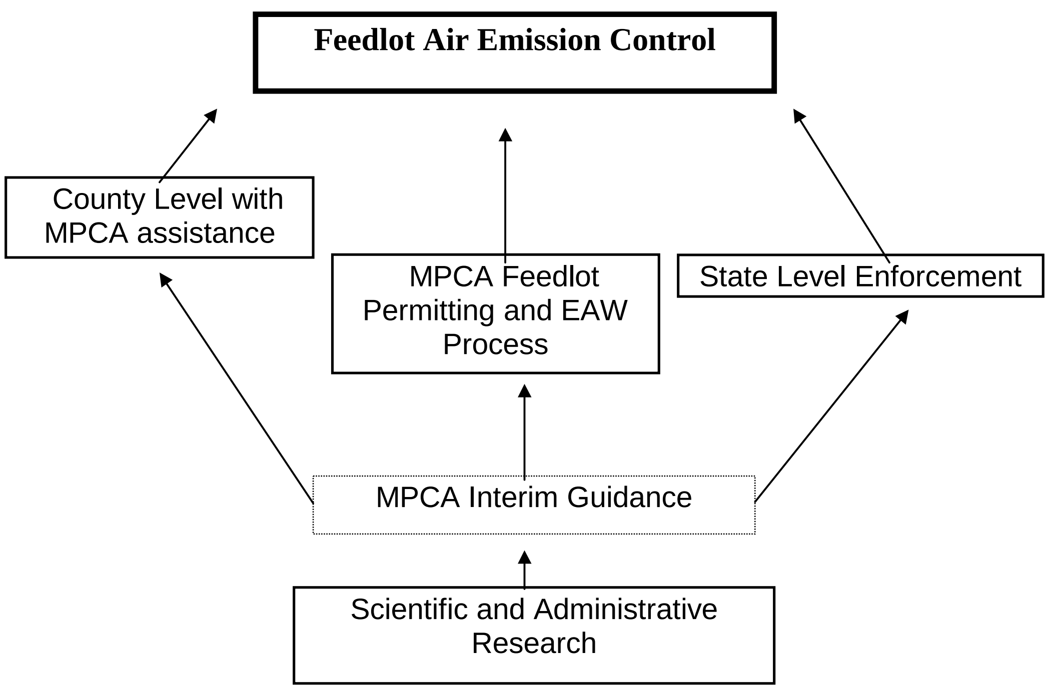
Under the general permitting rules (Minn. R. 7001.0140, Subp. 2), the MPCA cannot issue a permit if the permittee will not comply with all applicable state and federal pollution control statutes and rules administered by the MPCA, or if the facility operation under the conditions of the permit will endanger human health or the environment. This raises a new challenge in the review and issuance or reissuance of feedlot permits with respect to feedlot air quality. Producers must provide some assurance that their proposed or existing feedlot will stay in compliance with the state hydrogen sulfide standards and will not exceed the proposed HRV for ammonia. Typically, this is accomplished through modeling, or the implementation of a preventative action, and may include air monitoring. Each decision is based on the specifics of the facility and the proposed mitigative measures. The air emission measures are incorporated into the permit and become enforceable provisions.

VI. Feedlot Air Quality Program Goals and Objectives

A. Feedlot Air Quality Goals and Objectives

The goal of controlling feedlot air emissions is in part, compliance with the ambient hydrogen sulfide standard, reduction of odor to a socially appropriate level, and to minimize atmospheric emissions that may have regional and global environmental effects.

Figure #11
MPCA Feedlot Air Emission Control Development Model



These emissions are currently regulated by the MPCA through the feedlot permitting and environmental review process, as well as through various compliance and enforcement activities related to the ambient hydrogen sulfide standard. County programs may also regulate air emissions through various means including the conditional use permit process, setback distance, and nuisance regulation.

One of the barriers to controlling feedlot air emissions is the uncertainty that exists in the application of various mitigation technologies, the cumulative impacts of air emissions from multiple feedlot facilities, questions involving the administration of these issues at the state and local level, and how to develop better guidance for addressing future feedlot air quality issues.

With these uncertainties in mind, as well as the immediate need to address feedlot air quality issues at a local level, the Feedlot Air Quality Work Group (Work Group) has identified the following two objectives that will help advance the control of feedlot air emissions:

- foster the development of feedlot air quality control at the county level;
- identify areas of scientific and administrative research that will further feedlot air quality control, and develop MPCA interim guidance during the research phase to assist in the feedlot permitting and environmental review process.

The following discussions in this section illustrates how the MPCA shall meet these objectives and develop effective and practical state and local feedlot air emission control.

1. Developing feedlot air quality control at the county level

In an effort to better address the feedlot air quality issue, the Feedlot Air Quality Work Group has recommended that the MPCA facilitate and encourage implementation of an odor control regulatory mechanism at the county level.

The Feedlot & Manure Management Advisory Committee (FMMAC) has addressed the feedlot odor issue through the formation of the Livestock Odor Task Force (LOTF). The LOTF submitted a strategy for addressing livestock odor issues (LOTF, 1997). The strategy makes recommendations regarding odor policy and how to implement an odor regulatory program at the county level.

The implementation of this process will require technical and regulatory support from various units of state government and the University of Minnesota. An implementation plan will be developed with county input in 1999. Some of the county level odor program development topics that will require further discussion and research are complaint response, odor measurement/evaluation, odor mitigation, conditional use permits and related regulatory methods.

In the interim, the Feedlot Air Quality Work Group proposes that the MPCA forward a copy of the incoming odor complaints to the appropriate county staff, redacted to eliminate the identity of the complainant. The identity of the complainant is confidential information under Minn. Stat. § 13.44. The MPCA would also notify the feedlot owner or operator that a complaint has been made, and that MPCA and/or County staff may be conducting air monitoring to detect if there is a potential to exceed the state standard for hydrogen sulfide.

The county may also be able to address the issue through alternative means such as existing odor regulations or conditional use permit conditions designed to address feedlot odor issues. The benefit of a parallel complaint response would provide for quicker response time, and potentially a wider range of technical and enforcement tools to address the odor concern.

2. Research needed to develop feedlot air quality control

One of the major issues facing the MPCA in the issuance of a feedlot permit is question whether to mitigate air emissions, monitor, or both. Currently, the body of research and data used to make these decisions is incomplete. The MPCA is developing interim guidance to assist feedlot permitting staff and management on this issue until a matrix or similar tool can be developed. During this interim period, the MPCA will coordinate a feedlot air emission mitigation research group with other state agencies, environmental groups and private sector stakeholders that will evaluate various mitigation methods, setback distances, animal housing design, and size. This research will ultimately replace the interim guidance with a mitigation/monitoring matrix based on field data and research that will be used by the MPCA, project proposers and producers to evaluate feedlot air emissions and determine if monitoring or mitigation is required. The matrix will be composed of various factors including facility size, animal type, animal housing style, manure storage method, setback distance, and down wind receptors.

The MPCA is currently developing a strategy to coordinate the research group effort. This research shall be focused on all sectors of the livestock production industry.

3. MPCA permitting and environmental review interim guidance

Until a functional mitigation/monitoring matrix is developed, the MPCA must rely on interim guidance to assist feedlot permitting, enforcement and environmental review staff in addressing air quality issues. The MPCA has already developed an interim guidance with respect to addressing cumulative effects of feedlot air emissions (Appendix I). The remaining issues pertaining to mitigation, monitoring and enforcement will be addressed in the Spring of 1999.

The MPCA is also moving to an "outcome based" rather than a "prescriptive measure" style of feedlot permitting with respect to air quality. Outcome based permitting provides greater flexibility by allowing a producer to choose a mitigation method or management practice to keep their facility in compliance with the state ambient standard.

B. Compliance and Enforcement

1. Education and Outreach

One of the most effective tools for achieving and maintaining compliance is through proactive outreach and educational efforts. The MPCA will continue to develop and use this venue to educate the public about the state standards, mitigation technologies and related feedlot air quality issues. MPCA staff intend to continue educating and training county staff, producers and interested parties on the various feedlot air quality issues. This is accomplished through the various speaking opportunities, as well as through individual meetings with feedlot facilities which have shown a potential to exceed the state ambient standards for hydrogen sulfide. The MPCA is also planning several technical workshops on continuous air monitoring during 1999.

2. Complaint Response

A practice of attempting to visit and monitor each site which has been identified by a complaint has been followed through the 1998 air monitoring season. This procedure will continue to be followed until other methods are available to determine compliance with the hydrogen sulfide standard. The MPCA is in the process of implementing a regional feedlot odor complaint response to better address feedlot odor complaints.

3. Field Screening

The Jerome Meter will continue to be the appropriate tool for initial hydrogen sulfide compliance screening. Its portability and accuracy of the meter allow the MPCA to get "snapshot" readings of many feedlot facilities in an efficient manner over a short period of time. The tool is useful for identifying facilities that have a potential to exceed; however, because the Jerome Meter is not approved for official compliance monitoring, a low Jerome Meter reading does not necessarily demonstrate compliance with the ambient hydrogen sulfide standard.

The MPCA is in the process of providing a regional feedlot odor complaint response with the use of a Jerome Meter. MPCA Staff will address feedlot odor complaints with Jerome Meters located at the regional and sub-regional offices to improve response time.

4. Continuous Air Monitoring

MPCA CAM's will continue to be used at as many of the sites showing a potential to exceed as resources allow. Facilities having a potential to exceed which choose not to take preventative actions will be required to demonstrate compliance using a CAM. Violations detected will result in a site specific enforcement decision.

5. Compliance and Enforcement Tools

Enforcement is conducted on a case by case basis. As with all enforcement throughout the MPCA, a team of staff evaluate the details pertaining to each case to determine what corrective measures are necessary and, if applicable, the amount of any monetary penalty. This evaluation will continue on a case by case basis. The hydrogen sulfide enforcement response plan indicates that a violation of the state standard for hydrogen sulfide will be followed by enforcement which may include corrective actions, a monetary penalty or a combination of both. The purpose of the corrective action is to mitigate environmental or public health harm associated with a violation. Monetary penalties serve to recover any economic benefit gained by the noncompliance, to reduce competitive advantage, and to deter future noncompliance. The MPCA has found that this strategy is an effective one.

The Memorandum of Understanding (MOU) was developed in 1998 as a tool for documenting preventative actions at feedlot facilities that have demonstrated a potential to exceed the ambient hydrogen sulfide standard. The Work Group has proposed that this process be modified. The process of finalizing an MOU may not be the most efficient way of ensuring that hydrogen sulfide is controlled at specific facilities. Facilities which demonstrate a potential to exceed in 1999 will be asked to submit a mitigation plan. The mitigation plan may include air monitoring and will be subject to MPCA approval. These requirements are similar to those that were required in the 1998 MOU process; however, the process is less formal and should require less time. The plan will need to be amended and approved when conditions on the site change and will continue during the operational life of the facility. If a facility requires a new permit, the hydrogen sulfide issue must be addressed accordingly. It has not yet been determined as to how this issue should be addressed, however, one recommendation is to incorporate the mitigation plan into the feedlot permit in lieu of an air monitoring or mitigation requirement. The approved plan would become an enforceable requirement upon incorporation into a permit.

For facilities with existing feedlot permits that have demonstrated a potential to exceed the ambient hydrogen sulfide standard, the MPCA can modify the feedlot permit to include a mitigation plan that may require air monitoring.

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