ODOR MANAGEMENT PLANS FOR DAIRY OPERATIONS

PURPOSE

An odor management plan is a systematic inventory of potential odor sources followed by an assessment of relative potential of odor generation from the identified sources as well as relative to other potential sources, identification of effective control strategies to reduce odors from these potential sources, and finally, establishment of a definite protocol for implementing the control strategies. Essentially, an odor management plan will have the following six elements:

1. Cover Sheet
2. Identification/inventory of potential odor sources on the facility.
3. An outline of rating and ranking of these potential sources.
4. Identification of effective control strategies for each of these odor sources.
5. Establishment of a protocol(s) to implement identified control strategies.
6. Development of a protocol to respond to odor complaints.

1.0. COVER SHEET

The cover sheet provides the identity of the facility whose odor management plan is being developed and should, therefore, provide the following information:

1. The name of the facility, physical address, and other contact information
2. Owner and operator
3. Plan preparer's name and signature
4. Preparers organization/institution (consulting firm, university, etc)
5. Name and signature of reviewer (if any)

2.0. INVENTORY

In livestock facilities, nuisance odors can result from a single odor source, a single odor event, or the combination of several sources and events. Therefore, it is important to conduct a thorough inventory of all odor sources on-site in a systematic way to ensure that all potential odor sources are identified in this exercise.

In general, however, odors from livestock facilities primarily originate from either; (i) manure storage structures, (ii) indoor animal housing, (iii) open lots animal housing, or (iv) land-application of manure. Other secondary sources that inadvertently may be overlooked in assessment of nuisance complaints include dead animal disposal sites, silage piles, feed centers, and any other storage areas of bulk organic matter. Operations on the facility (e.g., manure agitation, solids-liquid separation, etc) likely to generate odor should also be identified during inventory because often these events, though infrequent, can be the source of significant odor emissions and thus generate odor complaints. Strategies to deal with these events go a long way in alleviating odor nuisance situations and complaints.

A brief description of each odor source should be included in the inventory. This description should include the size of the odor source (physical area) and its location and orientation relative to other potential sources, prevailing wind-directions, roadways, neighbors, property boundaries, and other public properties. A map is probably the easiest and most clear way of quickly presenting the potential odor sources relative to each other and relative to potential receptors (neighbors, public facilities, etc) in the site's proximity. A map is, therefore, always included in an odor management plan. Ideally, the map should include:

1. The basic global orientation with "North" indicated by the usual directional-arrow, and the scale of the map.
2. Locations of all potential sources odor, namely: confinement barn, open lot, manure storage, compost sites, mortality holding or disposal sites, land application, silage piles, feed centers, manure processing centers, manure treatment centers, and any other sites holding organic materials.
3. Locations of receptors within 2 miles of the animal facility (homes, schools, churches, businesses, recreational facilities, etc).
4. Locations of shelter belts, hills, or other sudden changes in topography that influences odor dispersion.
5. With help of directional arrows, indications of prevailing wind directions at different times of the year (summer, spring, or during manure application periods, etc). Local weather stations can provide this kind of information.
6. Special identification of any receptors whose elevation is below a potential odor source(s) to emphasize high-risk locations.

<u>3.0. ODOR RATING/ASSESSMENT</u>

An odor management plan must also identify potential "rating" that each of the identified potential on-facility odor source has to create nuisance odors. Because some odor sources emit more intense odor per unit area than other sources, both relative odor emissions and the size of the odor source must be considered in determining the actual potential of odor nuisance from each odor source. Intermittent events, such as liquid manure agitation and pumping or land application, also cause relatively high odor emissions and should be considered in the development of a list potential odor sources.

Other factors to consider in determining potential rating and/or ranking of odor sources include: proximity of the sources to public areas or neighbors, and dilution of odors caused through the mixing of odors with ambient air, which is usually a function of distance, topography, and meteorological conditions. Increased distances between odor sources and the public will result in fewer nuisance complaints. Topographical features can either enhance dilution or reduce dilution depending on the particular feature. Wind breaks or tree lines encourages mixing of the odorous air with clean air, whereas valleys or low areas may reduce odor dilution. Meteorological conditions also affect dilution. Maximum dilution occurs when the cool air near the ground is heating and rising. On the other hand, during the late evenings when it is calm and the atmosphere is cooling, the odorous air is trapped near the ground and there is little dilution. Of these three factors; distance, topography, and meteorology, separation distance will likely have the biggest impact on nuisance complaints.

3.1. Assessing relative odor potential

Different criteria on the assessment of relative odor potential generation are in use in the United States. However, the goal is the same: to identify the potential of each source to generate order and eventually to identify the sources of odor in the order of their odor generation potential relative to each other. These "ratings" and "rankings" provide a guide to the development of odor control strategies. Tables 1, 2, 3, and 4 in the appendix provide one such systematic guide of assessing the potential of each source to generate odor by identifying the potential of each identified source as either: low potential, medium potential, or high potential. Other factors such as surface areas (size), frequency, duration, intensity, etc are needed to generate a listing of relative odor rating.

4.0. ODOR CONTROL STRATEGIES

Odor control technologies can be put in three different categories depending on their mode of operation: (i) those that reduce generation of odors, (ii) those that decrease emission of odors, and (iii) those that increase dilution of odors. Several of these technologies are listed in Table 5 in the appendix. This listing is by no means exhaustive. Since many of these technologies are still in development stages, the odor management plan should list one, two, or possibly three alternative-control technologies for each of the high and medium potential odor sources, i.e. a tier system control strategy. If the first odor control technology proves ineffective, then the second or third technologies can be implemented in turn.

4.1. Technologies Reducing Odor Generation

Control technologies that reduce the production or generation of odorous gases include: manure treatment technologies such as anaerobic digesters or aeration systems, diet manipulation to reduce the amount of manure produced or the amount of nutrients in the manure, or chemical or biological additives. Manure treatment technologies can be very effective at odor control but are typically expensive. Chemical additions can also be effective, and the cost depends on the specific chemical and the frequency of addition. Biological additives are typically less expensive than manure treatment or chemical additives, but their effectiveness has not been well documented.

4.2. Technologies Reducing Odor Emissions

Technologies considered to reduce emissions usually capture and convert the odorous gases to non-odorous gases before they leave the site by either biological, physical, or chemical processes. A good example is a biofilter whose media holds microorganisms which degrade emitted odorous gases to non-odorous gases immediately after the emitting source. The air emitted from a biofilter in good working condition is nearly odor free.

4.3. Technologies Increasing Odor Dispersion

Technologies that disperse and dilute odors include shelterbelts, windbreak walls, and setback distances. Increased turbulence caused by the shelterbelts or windbreaks and possible capturing of the odorous gases on the tree foliage are believed to be the causes of odor reductions downwind.

4.4. Good House-Keeping Practices

In addition to and before enlisting the help of established advanced and invariably capital intensive odor control technologies, the first line of attack in controlling and managing odor is through good house-keeping practices. Some refer to this as “common sense” approach. The following is a check-list of some good house-keeping practices or “common sense” approaches. Again, the list is by no means exhaustive and other innovative good house-keeping practices by each operator are encouraged.

1. Locate manure storage or lagoon near center of cropping area or other remote areas instead of near livestock housing.
2. Block visual line of site from neighbors and public roads to farm facilities.
3. Maintain good surface water drainage away from animal confinement and manure storages.
4. Ensuring that facility is thoroughly washed down between animal groups.
5. Ensuring flush tanks are covered or totally enclosed.
6. Ensuring flush tanks have fill pipe extended to near bottom with anti-siphon vents.
7. Ensuring spilled feed is regularly cleaned up.
8. Ensuring mortalities are removed quickly and disposed off in an appropriate manner.
9. Preventing up-slope water and roof water from entering lot.
10. Ensuring that all low spots within a corral drain quickly.
11. Avoiding use of lot surfaces as part of the settling basins or for storage of runoff.
12. Regularly filling and packing low spots to prevent mud holes.
13. Ensuring frequent removal of old feed from bunk feeders and spilled feed on the ground.
14. Construction of feeders to allow drainage of all precipitation.
15. Ensuring lagoons are properly sized, properly managed, and properly maintained.
16. Ensuring manure discharge extends to below the surface of lagoons.
17. Ensuring environmental conditions are monitored during agitations and applications.

5.0. DEVELOPING PROTOCOLS TO IMPLEMENT CONTROL STRATEGIES

A good odor management plan should aim at tackling the high potential odor sources first and using the least expensive but effective proven technologies. However, most of the odor sources identified as “low potential” most usually requires only minor (or no) changes in management practices and invariably low capital investment if any. In other words, simultaneously taking care of the “low potential” odor sources that requires low (or no) investments where necessary will usually highly complement the odor control strategies adopted for the “high potential” sources.

The first task would be, therefore, to list odor sources rated “high potential”. Once this listing is complete the plan should next identify the “relative” potential of these sources based on other factors such as size, intensity of odors, odor frequency, odor persistence, etc. At least three potential control strategies are then listed next to each of these ranked sources. From these three, the cheapest but proven technology is selected as the tier 1 in the control strategy, the next cheapest technology is marked as the tier 2 in the control strategy if first technology does not produce acceptable results, and finally the third technology is put to work if the first two technologies prove ineffective or unacceptable.

This iterative procedure of drawing protocols to implement identified control strategies is adopted for the remainder of potential odor sources going down from the high potential, medium potential and finally to the low potential sources (i.e. if the “low potential” were not tackled together with the “high potential” sources. Each of these implementation schemes should identify a time frame, assessment of effectiveness, and the person(s) responsible for overseeing their implementations.

This is by no means the only approach into putting together protocol(s) for implementing effective control strategies but gives an example of a likely process. The bottom line is to provide a road map into achieving the goal of the odor management plan: to reduce odor from the livestock facility to acceptable levels with respect to neighbors and general public.

6.0. ODOR COMPLAINT RESPONSE

This often overlooked element is perhaps one of the most important elements of an odor management plan. A protocol to address odor complaints is needed; (i) to separate serious odor complaints resulting from excessive odor emissions from odor complaints registered by disgruntled neighbors during non-odor events, (ii) to determine how many valid complaints are needed to trigger the implementation of an odor control technology, and (iii) to establish some method for monitoring the effectiveness of the technology. The complaint response protocol, therefore, sets up an odor monitoring plan, sets guidelines for an acceptable number of odor events and establishes some method to evaluate effectiveness of odor control technologies. All the gains from adoption of good control technologies may not be realized unless a good relationship with neighbors and public is cultivated and maintained. An odor management plan should, therefore, at least include the following six odor complaint response strategies:

6.1. Avoiding Odor Complaints

The first line of defense is of course to avoid odor complaints by making an effort to control odor emissions, including peak odor events such as manure agitation or land application of manure. These efforts and their perceived effect on odors should be documented. A record of odor complaints and actions taken to respond to those concerns should be kept by the producer.

6.2. Establishing a Relationship with Neighbors and Community Members

An effective complaint response protocol requires objective inputs of neighbors and other community members such as environmental service specialists, county feedlot officers, and county and township officials. These individuals provide an honest evaluation of farm odor impacts. They could be listed on the odor management plan and help in the development of the complaint response protocol. A team approach fosters communication and flow of information which is critical to responding to complaints.

6.3. Monitoring of Odor Events

Monitoring odor events will help verify odor complaints and identify odor sources. Monitoring might include scheduled drives around the farm perimeter with a notebook recording the date, time, and location of the monitoring and the strength of any odors that were detected. Other monitoring might include record keeping of odor events by neighbors or community members. Strength of odors can be recorded on a three point odor intensity scale where 1=detectable odors, 2=recognizable odors, and 3=very distinct and annoying odors.

6.4. Set Acceptable Intensity and Frequency Standards

Since odors are a part of all livestock and poultry farming enterprises, it is impossible to expect a 100% odor free air around the farm. However, frequent odor events of high intensity are unacceptable. Therefore, some reasonable frequency of odor events should be established. This frequency could include a given number of odor events per month or per year that are acceptable. Above this frequency, the odor management plan would be implemented. Establishing the acceptable frequency and intensity (how often and how strong) of odor events should be done with input from neighbors and community members so everyone is familiar with the goals of the farm.

6.5. Evaluate the Odor Control Technology

After an odor control technology has been implemented, an honest evaluation of its effectiveness is needed. A complaint response protocol will outline evaluation methods and techniques. This exercise is similar to Strategy 6.3 (Monitoring Odor Events) above.

6.6. Keep records of odor control technologies

Keep records of all odor control measure adopted along the way. This is important especially if the facility has had odor complaints before and where litigations are likely to arise. Again, sharing with the neighbors information on substantial investment in odor control strategies also is not a bad idea; it shows that you are concerned about potential problems and simultaneously also acknowledge them as stakeholders. You want them on your team!

Table1. Assessment of Potential Odor Generation in Dairy Operations
(Manure Storages)

Potential source	High potential	Medium potential	Low potential
Manure storage system(s)	Formed storage, earthen basin, or undersized lagoon [ ]	Properly sized lagoon, partially covered storage, open lot runoff pond, or separate storage for solids and separate liquids [ ]	Anaerobic digester, purple anaerobic lagoon, covered composted/dry manure, Less than weekly storage before application, or properly covered storage [ ]
Location of storage relative to indoor or open lots	Downwind or upwind placements [ ]		Remote or prevailing winds or ventilation fans do no vent air across storages or lagoons [ ]
Storage location	Clearly visible to the neighbors/public [ ]		Hidden or screened from neighbors/public view [ ]
Storages/earthen basins manure surfaces	Exposed and does form a crust AND storage is loaded above liquid surface [ ]	Storage is loaded below liquid surface with partial crust formation [ ]	Storage is loaded below liquid surface with undisturbed crust cover the entire surface, or storage is enclosed tank [ ]
Agitation during emptying	Aggressive agitated by stream of manure directed above manure surface [ ]	Storage is agitated by stream of manure directed below the manure surface [ ]	No agitation during storage emptying [ ]
Atmospheric conditions during agitation	No consideration is given whatsoever [ ]	Agitation may be stopped when wind may result in odor problems, or during calm wind conditions or during evening hours [ ]	No agitation when wind may result in odor problems, or during calm wind conditions or during evening hours [ ]
Lagoon management	A permanent pool of 1/3 of the total volume or less is maintained [ ]	A permanent pool of at least ½ of the overall storage volume is maintained [ ]	Permanent pool never drops below “stop pumping point” to maintain permanent pool [ ]
Lagoon biological condition	Lagoon is dark brown or black and shows not signs of active bubbling during warm weather [ ]	Lagoon is dark brown or black and is actively bubbling from spring through fall [ ]	Lagoon is maintained in aerobic state or deep purple or red colored lagoon [ ]
Lagoon loading frequency	Less frequently than weekly or loading rates are highly variable [ ]	Loading is at least weekly with fairly similar loading rates [ ]	Lagoon is loaded daily with fairly similar loading rates [ ]
Lagoon unloading	Infrequent or not at all due to evaporation and seepage matching liquid additions [ ]	Annually to permanent pool marker [ ]	Annually to permanent pool marker and in dryer years lagoon pumped below pool marker and fresh water adder to marker [ ]
Settling basins or channels	Liquid pools often remaining for multiple weeks [ ]	Liquid pools often remaining for multiple days [ ]	All liquid drains and a dry solid surface is obtained within a few days after a storm [ ]
Open channels for transporting runoff	Liquid pools often remaining for multiple weeks [ ]	Liquid pools often remaining for multiple days [ ]	All liquid drains within a few days after a storm [ ]
Stockpiled manure location	Precipitation and seepage pools in vicinity of stockpiles [ ]		All precipitation and seepage drains away from stockpiles [ ]
Stockpiled manure conditions	Manure stockpiled wet and never turned [ ]	Wet stockpiled manure is turned less than once weekly to promote composting [ ]	Manure stockpiled dry (<40% moisture), or a dry organic residue is mixed with wet manure before stockpiling, or stockpiled manure is turned weekly to promote composting until no additional heating occurs [ ]
Others:__________			

Table2. Assessment of Potential Odor Generation in Dairy Operations (Indoor Housing)

Potential source	High potential	Medium potential	Low potential
Manure collection system	Slurry or liquid [ ]	Solid with little or no dry organic matter additions [ ]	Solid with adequate dry organic matter addition [ ]
Manure removal frequency	Less than once a week [ ]	Once a week [ ]	Once a day or well-bedded to maintain dry conditions [ ]
Manure collection and containment	All manure regularly pools or accumulates in areas around animal housing [ ]	Some manure occasionally pools or accumulates in areas around animal housing [ ]	All manure is contained within housing and not allowed to collect around animal housing [ ]
Dust minimization*	No efforts have been made to control dust [ ]	Some efforts have been made to control dust [ ]	Considerable efforts have been made to control dust [ ]
Feed spillage	Considerable feed spillage [ ]	Some feed spillage [ ]	No feed spillage [ ]
Others:			

*Diet contains significant amounts of fat or oil (e.g. 50 lb/ton or more added fat); Liquid feeding systems; Drop tubes used on all augers; Housing is sprayed with vegetable oil daily; regularly clean ventilation fans, louvers, and fan housing.

Table 3. Assessment of Potential Odor Generation in Dairy Operations (Open Lots Housing)

Potential source	High potential	Medium potential	Low potential
Corral slope	No slope or slope is toward feed apron or other feed areas [ ]	Slope is < 3% and away from feed apron and other feed areas [ ]	Slope is 3 to 5% and away from feed apron and other feed areas [ ]
Adjacent pens	Pen-to-pen drainage is common [ ]	Some pen-to-pen drainage occurs [ ]	No pen-to-pen drainage at all [ ]
Corral surface	Corral soil is easily erodable and prone to rills and gullies [ ]	Corral surface is soil treated with stabilizer or constructed or firm, stable soil [ ]	Corral is concrete paved [ ]
Drainage from corral	Downstream corral surface are part of the runoff storage pond [ ]	Downstream corral surfaces are prone to temporary flooding [ ]	Downstream corral surfaces quickly drain after a storm [ ]
Runoff control	Significant manure or runoff regularly pools in areas around open lots [ ]	Some manure and runoff regularly pools in areas around open lots [ ]	All manure or runoff is contained within runoff pond [ ]
Vegetative barrier	No vegetative barrier is located downwind of corral based on prevailing winds [ ]	Some vegetative barrier is located downwind of corral based on prevailing winds [ ]	A dense shelter or other vegetative barrier is located downwind of corrals based on prevailing winds [ ]
Frequency of manure removal	Less than twice a year [ ]	4 – 6 months intervals [ ]	Every 2 months or less [ ]
Water leakages	Overflow waterers and system leaks are not a priority [ ]	Inspections for overflow waterers and system leaks are infrequent [ ]	Regular inspection are made for overflow waterers and system leaks and problems quickly corrected [ ]
Manure ridges at fence lines	Removal of manure ridges is not a priority [ ]	Manure ridges removal after a couple of pen cleanings [ ]	Manure ridges are removed with each open cleaning [ ]
Dust control measures*	No dust control measures are implemented [ ]	One to three dust control measures are taken [ ]	At least four dust control measures are taken [ ]
Others:			

* (1) Cross-fencing to increase stocking density; (2) Daily watering or chemical resin application to access roads; (3) Daily watering of corral surfaces; (4) Dry manure and dust harvested frequently; (5) Topical application of crop residue on corrals; (6) Alter feed schedule (avoid late afternoon and evening feeding).

Table 4. Assessment of Potential Odor Generation in Dairy Operations (Land Application)

Potential source	High potential	Medium potential	Low potential
Spray irrigation	Irrigation from manure storages or overloaded anaerobic lagoons [ ]	Irrigation from well designed and normally operated anaerobic purple lagoons [ ]	Irrigation from aerobic lagoons [ ]
Spray nozzle type	High pressure big guns [ ]	Medium pressure close to crop canopy [ ]	Low pressure nozzles close to crop canopy [ ]
Hose application of manure slurry	Surface application [ ]	Surface and same day incorporation [ ]	Surface and immediate incorporation [ ]
Solid manure spreading	Surface application of wet solid manure [ ]	Surface application of relatively dry solid manure [ ]	Surface application of dry solid manure OR immediate incorporation of wet manure [ ]
Application: Atmospheric conditions	No consideration is given whatsoever [ ]	Application may be stopped when wind may result in odor problems, or during calm wind conditions or during evening hours [ ]	No application when wind may result in odor problems, or during calm wind conditions or during evening hours [ ]
Application: Weekends/holidays	No consideration is given at all [ ]	Applications during these days are usually avoided [ ]	Applications during these days are totally avoided [ ]
Application: raw/dilution	No dilution [ ]	Medium dilution (< 3:1 fresh-water to lagoon water [ ]	High dilution (> 3:1 fresh-water to lagoon water [ ]
Others:			

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Table 5. Common odor control technologies

Control strategy	Description
Biofilters	Odorous gases are passed through a bed of biofilter medium; bacteria and fungal activity help to degrade organic volatile compounds.
Biological and chemical wet scrubbers	Odorous gasses are passed through a column packed with different media types; water (and/or chemical) is sprayed over the top of the column to help optimize biological and chemical reactions.
Diet manipulations	Enzymes added to diet to improve nutrient utilization; diets formulated to reduce crude protein content; or other changes in diets to enhance digestion.
Fat additions	Dust reduction and subsequent odor reduction by adding fat to the feed.
Bio-additives	Biological products are added to the manure to oxidize/degrade odor precursors to odorless compounds.
Frequent manure removal	Fresh manure (fewer than 5 days old) usually produces less odor than stored manure.
Nonthermal plasma	Odorous gases are oxidized to odorless gases when passed through plasma.
Oil sprinkling	Vegetable oil is sprinkled daily at low levels in the animal pens.
Ozonation	Ozone is added to the ventilation air to oxidize the odorous gases to odorless gases.
Shelterbelts	Rows of trees and other vegetation are planted around a building, thus creating a barrier for both dust and odorous compounds emitted from the building exhaust.
Windbreak walls	A solid or porous wall constructed 10 to 15 feet from the exhaust fans will cause dust to settle out and will also help disperse the odor plume.
Aerobic treatment	Biological process where organic matter is oxidized by aerobic bacteria; mechanical aeration is required in order to supply oxygen to the bacterial population.
Anaerobic digestion	Biological process where organic carbon is converted to methane and carbon dioxide by anaerobic bacteria under controlled conditions of temperature and pH.
Floating clay balls	Floating clay balls cover the manure surface to reduce emission.
Geotextile covers	Geotextile membranes are placed over the surface of the manure to reduce emission.
Natural crust	Dairy and sometimes swine storage basins can form a natural crust. This crust will reduce odor emissions.
Impermeable covers	Non-porous cover floated on, or suspended over, the liquid surface. Covers trap gases before they escape. Gases must be drawn off and treated using biofilters or wet-scrubbers.
Solid-manure composting	Biological process in which aerobic bacteria convert organic material into soil-like manure called compost; it’s the same process that decays leaves and other organic debris in nature.
Solids-liquid separation	Solids are separated from liquid slurry by sedimentation or mechanical separators.
Straw covers	An 8-12 inch blanket of dry wheat, barley, or other good quality straw floated on the manure surface reduces emissions.
Manure incorporation or injection	Manure is incorporated immediately after land application or manure is injected under the soil surface.
Chemical additives	Chemicals added during agitation to reduce hydrogen sulfide (e.g. chlorine, potassium permanganate, hydrogen peroxide, iron, and zinc salts) or ammonia emissions (acids).
Mortality composting	Carcasses are buried in sawdust or some other organic composting material.

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