Protection Distances for Sufficient Dispersion and Dilution of Odor from Swine Buildings

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Odor from a swine operation is caused by decomposing manure, rotting feed, incineration, dust emissions, and dead pigs. The control of odor is a significant issue for pork producers (Miner and Barth, 1988). The important aspects for neighbors are intensity, duration, and frequency of detection of the odor. To be considered a nuisance odor, it must be offensive to the senses and materially interfere with the comfortable enjoyment of property within the area.

It is impossible to eliminate all odors from hog production because the technology to completely remove it either does not exist or is prohibitively expensive to install and/or to operate. Certainly, good design and management and certain odor control technologies can minimize odor, but the best control for remaining odor is to allow outdoor air movement to dilute the odor with distance. Therefore, the most critical and effective means of reducing odor complaints occurs in initial site selection.

Van Kleeck and Bulley (1990) conducted a survey of neighbors around seven, 100- to 225-sow, farrow-to-finish operations to assess the relationship between the perception of odor nuisance, separation distance, and the size of the facility. The frequency of swine farms perceived as a nuisance was inversely proportional to the square of the separation distance. About 20% of the neighbors living around 2200 ft away from a swine farm perceived it to be a nuisance. Farm size appeared to have no effect between 600 and 1200 ft away. Miner and Barth (1988) recommended a 1/2 mile setback for units with more than 1,000 pigs, otherwise 1/4 mile from neighboring residences, in all directions. According to the May 15, 1997 issue of the National Hog Farmer, required separation distances to dwellings in different states are as follows:

Kansas: 0.25 to 0.75 miles.
North Carolina: 0.38 miles is proposed.
Iowa: 0 to 0.47 miles.
Missouri: 0.19 to 0.57 miles.
Hughes County, S.D.: 2 miles from town, 5 miles from Pierre.
Oklahoma: .75 miles in the western half, .5 miles in the eastern half.

A proposed one mile setback was defeated in the Indiana legislature this year. The major problem with all these setbacks is that they impose a fixed distance upon all facilities regardless of topography; landscape; wind characteristics; age of pigs; type of feed, manure management or building ventilation systems used; or odor control technology used. Some don't even account for the size of the operation. There are many factors that influence odor perception by neighbors. Fixed setbacks do not consider wind direction. For example, confined valleys where sensitive sites are downslope of the facility are much more vulnerable than flat windy areas with no obstacles near the swine buildings (Shauberger and Piringer, 1997). Odor dispersion into the atmosphere is much better with vertical ventilation exhaust fans than with sidewall exhaust systems. Manure handling, treatment, storage and application techniques also have a major effect on the amount of odor generated by the operation.

These problems are not unique to North America. With both high human and animal populations, European countries have been faced wtih odor problems for many years. A new model for assessing airborne emissions resulting from livestock husbandry was developed for Austria by Schauberger and Piringer (1997). It calculates a reasonable assessment of setback distances for swine buildings. Here is the way it works. First, there is a rough estimation of the odor source by assigning the following parameters:

1. Number of pigs.

2. Animal factor ranging from 0.10 to 0.33 depending on pig weight. For example, assign 0.10 to a nursery pig and 0.33 to a sow.

3. Ventilation system factor ranging from 0.1 to 0.5. A tall vertical exhaust chimney system with high exit air velocity (a German standard) would be assigned a 0.1. Natural ventilation or sidewall exhaust fans (U.S. standard practice) would be assigned a 0.5 because the exhaust air comes out horizontally along the ground.

4. Manure treatment factor ranging from 0.10 to 0.27. This factor depends on the time that manure is kept in the building and the air flow pattern. A mechanically ventilated house with a totally slatted floor over a deep pit would perhaps be assigned a value of 0.27. However, this value could be decreased if a proven pit additive were applied to the stored slurry (Heber et al., 1997). A partially slatted floor over a shallow pit that is drained and recharged frequently would be assigned a value of about 0.15. Well managed straw bedding systems get the lowest values.

5. Feed management factor ranging from 0.05 to 0.20. The feed management factor is based on feed type (dry vs. liquid), storage and handling. Feed additives to reduce odor such as Yucca extracts really should be included here but were not mentioned by Schauberger and Piringer (1997).

The "odor number" is calculated by multiplying the number of pigs by the animal factor and the technical factor, which is a sum of the ventilation system, manure treatment and feed management factors. The odor number then represents the strength of the odor source. Doubling the number of pigs doubles the strength of the odor source but it does not double the recommended separation distance.

Next, odor dispersion around the source is estimated by considering wind distribution and influence of land slopes. Data from the nearest weather station is used to determine the regional wind patterns in eight directions (N,NW,W,SW,S,SE,E,NE). Local wind systems as determined by local topography and landscape are very important for dispersing odor. The "topographic situation" is assigned a score from 0 to 70 points and is direction-dependent. For example, a livestock building in a flat and windy area without any obstacles around it is dominated by the regional wind pattern so the "topographic situation" may be given a score of 0. A building located at the bottom of a narrow valley is at the other extreme for neighbors downslope and downvalley during night conditions. In this case, the "topographic situation" might be given a score of 70. The total score is determined for each of the eight wind directions by adding the "topographic situation" score to the frequency of wind. The dispersion factor is related to the total score and ranges from 0.6 to 1.0.

The land use factor ranges between 0.5 and 1.0 with 0.5 for commercial areas and 1.0 for pure residential areas. This factor is also direction-dependent.

The minimum protection distance is calculated by multiplying the square root of the odor number by 0.0155 and also by the dispersion and land use factors. For example, if the odor number is 100 and the dispersion and land use factors are 0.7 and 1.0, respectively, the minimum protection distance would be $\sqrt{100}$ *0.0155*0.7*1.0 = 10*0.0155*0.7*1.0 = 0.11 miles.

This model or guideline (Schauberger and Piringer, 1997) was used to determine the minimum and maximum possible odor protection distances for building sites with up to 12,000 pigs (Figure 1). The highest and lowest values for each factor were used for the worst and best cases (both extremely unlikely), respectively, to show the upper and lower bounds of the model output. For example, the lower and upper bounds for a site with 2500 pigs would be 0.07 to 0.44 miles (390 to 2300 ft), respectively (Figure 1).

A more likely calculation of odor protection distance is shown by the middle curve in Figure 1, which is based on the following assumed values:

1. Finishing buildings with animal factor = 0.27
2. Ventilation system factor = 0.40
3. Manure handling factor = 0.22
4. Feed factor = 0.1
5. Topographic situation score = 30
6. Frequency of wind = 12.5%
7. Land use factor = 1.0

Based on these "typical" factors for a finishing building in Indiana, recommended setbacks would be 0.17, 0.39 and 0.52 miles (915, 2046 and 2746 ft) for one, 1000 head finishing unit; four, 1250 head finishers; and nine, 1,000 head finishers, respectively (Figure 1). Of course, actual setbacks vary with site and with direction around the site.

To illustrate the directional nature of the model, the odor protection distance was calculated for all directions from a finishing facility. Hypothetical topography and land use factors and the wind frequency for Indianapolis in July were used (Table 1). The resulting odor production area is noncircular and may or may not follow prevailing wind patterns because of the effects of topography and land use. One can compare arbitrary setbacks of 1/2 mile and 1 mile to the direction-dependent setbacks calculated with this model and observe its greater efficiency and accuracy. These are shown in Figure 2, for 1,000, 4,000, and 10,000 head finishing units.

Discussion

Several European countries have established setback guidelines that assess the pollution around the source using the formalized judgment that the model described above provides. It should be noted that the Austrian guideline (Schauberger and Piringer, 1997) also specifies that a regulated protection or setback distance should not be applied in rural areas where livestock husbandry is common.

This type of model has application for the U.S. pork industry as a useful tool to assess reasonable distances for odor protection. The specific parameter values need to be studied and perhaps modified to more accurately reflect the true impact of proper management and odor control technologies used in the Midwest. Neighbor surveys and odor dispersion measurements should be conducted to validate the model. Then perhaps in our next legislative session, we can argue about the factors based on validated science instead of about unreasonable and arbitrary fixed distances, such as one mile vs. two miles!

References

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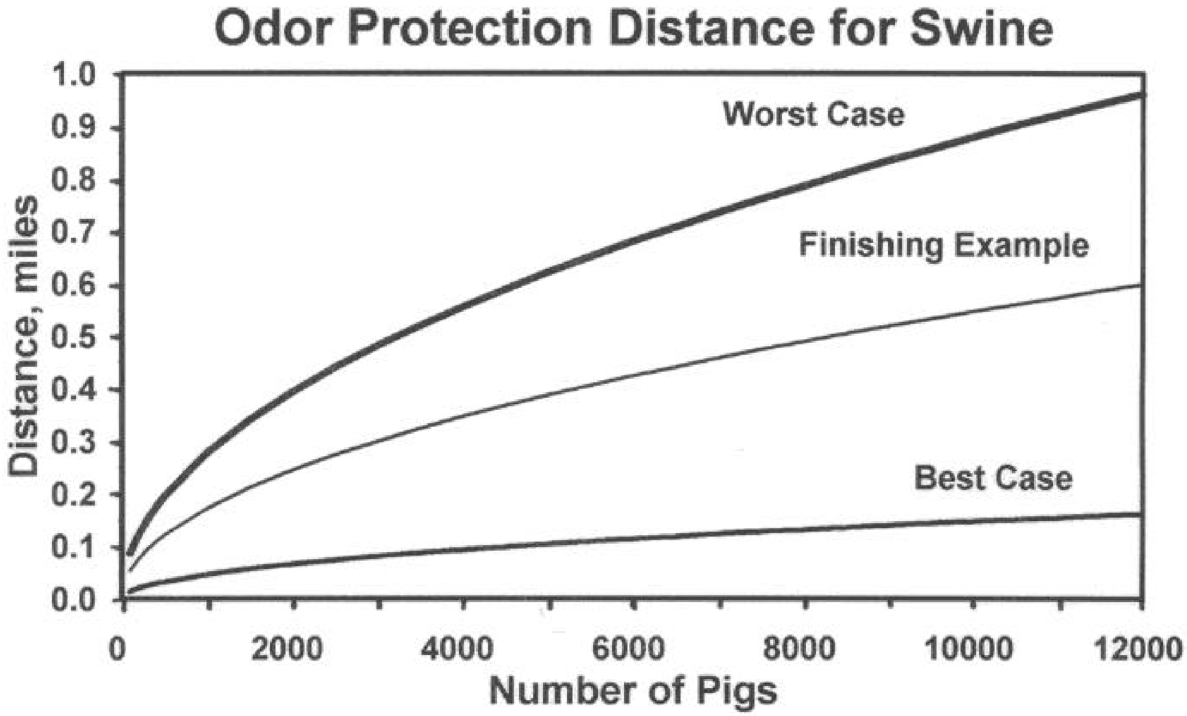

Figure 1. Setback distance recommended for hog units to sufficiently disperse odor emissions for neighbors using a parametric model (Schauberger and Piringer, 1997).

Table 1. Assumed topographical, wind frequency and land use factors for setback distances shown in Figure 2.

Direction	Topography score	Wind frequency	Total score	Dispersion factor	Land Use
N	15	10	25	0.7	0.5
NW	20	9	29	0.7	0.6
W	30	11	41	0.8	0.8
SW	50	21	71	1.0	0.8
S	45	14	59	0.9	1.0
SE	30	11	41	0.8	1.0
E	20	10	30	0.7	0.5
NE	15	10	25	0.7	0.5

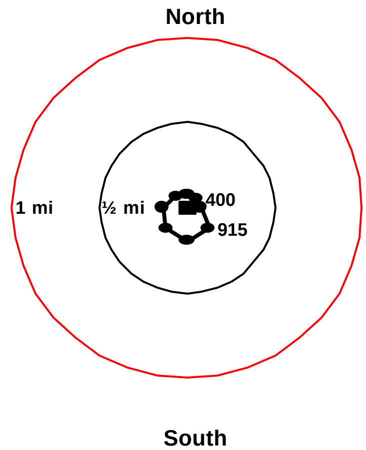

Figure 2a.

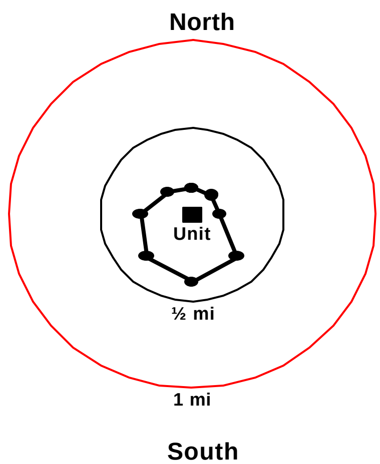

Figure 2b.

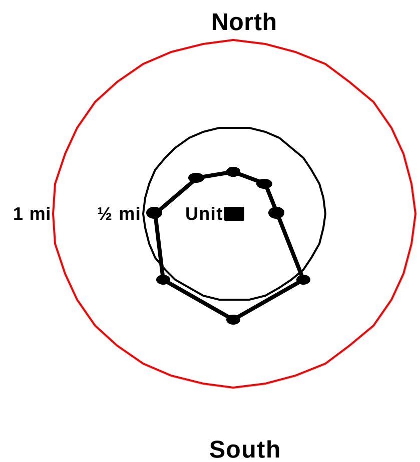

Figure 2c.

Figure 2. Directional setback distances calculated for (a) 1,000 head, (b) 4,000 head and (c) 10,000 head finishing units, with hypothetical wind characteristics and and land use factors as given in Table 1. Arbitrary 1/2 and 1 mile setbacks used or proposed by some governmental entities are shown for comparison purposes.