ODOR FOOTPRINTS AND THE ODOR FOOTPRINT TOOL
An Overview

Introduction:

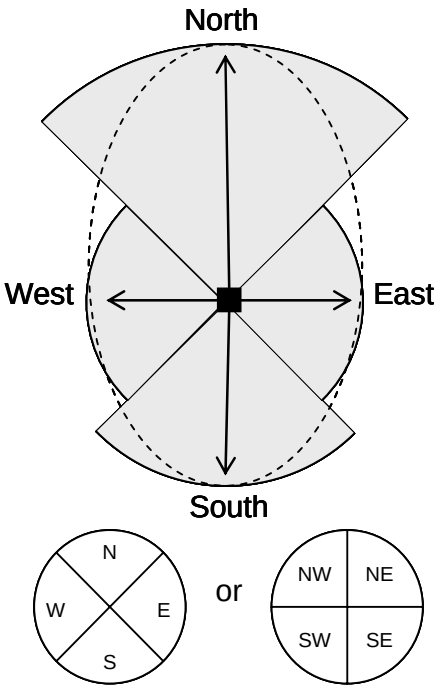
As animal production has changed and the facilities in which livestock and poultry are raised have grown in size, neighbors of animal feeding operations increasingly are expressing concerns about potential negative environmental effects on the surrounding rural community. Degradation of air quality is a prevalent concern, and the expected presence of offensive odors commonly is near the top of the list of issues and complaints. Livestock and poultry producers, community planners and officials, and rural residents in general, benefit from having objective, easily visualized information upon which to make well-informed decisions regarding odor impact, siting of facilities, and odor control. The Odor Footprint Tool is a planning and screening tool that can produce useful, science-based information, and help fill some of the void in objective information. This fact sheet provides a general description of odor footprints and the Odor Footprint Tool. The overview highlights the type of information conveyed, practical ways of representing setbacks and risk-based impact areas, the interpretation of risk-based odor impact, information needed to utilize the tool, and versions of the Odor Footprint Tool. More detailed information and instructions can be found in supplementary fact sheets.

Information Generated:

The Odor Footprint Tool provides minimum separation distances to maintain in four directions around animal production facilities to meet selected risk-avoidance targets. These ***directional setback distances*** extend to the north, south, east, and west of the given facilities (see figure); or to the northeast, southeast, southwest and northwest. The orientation of the setback distances aligns one direction with the direction of maximum exposure to annoying odors. The science behind the separation distances comes from the use of best-available research on the rates at which farm odors are given off, move and disperse, in conjunction with historical weather records from a representative location within an area.

Representing Setbacks and Impact Areas:

Directional setback distances are typically used to develop a simplified '***odor footprint***', which may be illustrated on a plat map or aerial photograph. An odor footprint provides a visual picture (top view) of the risk-based odor impact of livestock facilities. Specifically, it represents the area that is not expected to meet a selected target for avoiding odor annoyance. One way to show this is to draw quarter circles (shaded areas in figure), with the radius of each quarter circle being the respective directional setback distance. Quarter circles are relatively easy to produce and using this approach ensures consistency in showing setback distances. The risk-based impact area may also be shown as an oval, egg, or other smooth shape (dashed border in figure). Using a smooth shape removes sudden, unrealistic changes in the setback distance and shows a little less conservative impact area. It may be challenging, though, to draw a smooth shape on a site map and defend the choice.



Directional setback distances outline the expected extent of risk-based odor impact around a livestock odor source.

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The approach taken to show the risk-based impact area is left to the user of the directional setback distance information. A major goal for the Odor Footprint Tool was that it be easy to use. To avoid the tool being too complicated, time-consuming, and expensive for practical use in the field, the Odor Footprint Tool incorporates a number of simplifications - one of these being limited definition of the precise shape of the odor footprint. When odor footprints are produced directly from dispersion modeling, they tend to be irregular, lopsided, and variable in shape, which means that no one common shape will always convey the shape of an odor footprint better than another. If a more accurate and precise picture of the shape of the odor footprint is required, reference should be made to an odor rose or example modeled footprints for the region.

Risk-Based Odor Impact:

A risk-assessment approach is used to determine minimum separation distances for odor, and the expected frequency of exposure to annoying odor levels is the critical measure used in assessing odor impact. Frequencies of annoyance and annoyance-free conditions are expressed as the percentages of hours over extended periods of time during which odors are projected to exceed and not exceed, respectively, an established odor threshold level. As a frame of reference, each 1% is roughly 1 hour on average every 4 days.

A risk-assessment approach is employed for two reasons. First, the potential frequency of exposure is a definable measure that correlates well with nuisance complaints (and odor is primarily a nuisance issue). By analogy, the fact that a barking dog can occasionally be heard a half mile away may be interesting to know and illuminating a street sign with an orange-colored light may be unpopular, but neither is an objective indicator of annoyance. On the other hand, when the dog's bark exceeds a given sound level (decibels) at a neighbor's house a number of hours a week, or the orange-colored light shines brightly (as measured in lumens or foot-candles) into a neighboring area for several hours most evenings, objective and much more useful information is available upon which to frame discussions, assess alternatives, make decisions, and evaluate outcomes of actions. Odor annoyance is presently projected to occur whenever the odor intensity at a given location is 2 or stronger on a standardized 0-to-5 scale, with 2 being a faint odor that would typically only be detected after a period of time or if attention were drawn to it. Second, many rural residents and communities are already using weather-based risk assessments in planning and decision-making. For example, new construction must often consider the location of flood plains, minimum snow and wind loads, and heating/cooling degree days. The underlying principle behind using information from these weather-based risk assessments is that the resulting facility will perform as desired in all but the more extreme weather scenarios (e.g. a 50-year storm event). For practical reasons, most facilities are not designed to guarantee performance under all weather conditions and less-than-desirable performance is tolerated under relatively rare, extreme circumstances. Similarly, livestock operations need to be planned and managed to limit the likelihood of odors reaching annoying levels at neighboring residences, but there also needs to be some tolerance for relatively rare odor events that may be impractical to prevent.

Needed Information:

To obtain directional setback distances using the Odor Footprint Tool, some basic information is needed about the existing and/or proposed facilities, location with respect to available weather data, target risk-avoidance level for odor annoyance, and local terrain. This basic information is required to use both the worksheet-based and spreadsheet versions of the Odor Footprint Tool.

<u>Facility information:</u>

To determine directional setback distances, the types and sizes of facilities need to be specified. This information is used to estimate baseline rates at which odor is released from the facilities. 'Odor emission numbers' are associated with several common types of animal housing and manure handling facilities. An odor

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emission number represents the relative amount of odor released by the source facility into the air per unit of floor or surface area. Odor emission numbers are based upon odor measurements taken from several operating facilities within each facility type and include scaling factors that calibrate the underlying model projections with field measurements made by people trained to do 'odor sniffing'. The odor emission rate is also based upon facility size in terms of floor or surface area (top view). Facility size limits the number of animals that can be raised on a site and, for a given type of facility, is more closely associated with measured odor emission rates.

Some form of odor control may be implemented by the operation and this also needs to be considered. To account for the reduction in odor impact when utilizing a proven odor control technology, a representative odor control factor is applied, which reduces the overall odor emission rate and resulting directional setback distances.

Location and weather information:

Users of the Odor Footprint Tool must select a weather station location. The intent is that weather patterns that prevail at the selected station be reasonably representative of the proposed site. The Odor Footprint Tool determines directional setback distances based upon previously performed dispersion modeling using weather data for extended [typically 10-year] time frames.

The preferred option is to utilize historical weather records (actual meteorological data) from a representative weather station whenever this data is available. National Weather Service (NWS) stations are well-recognized sources of weather information, and modeling is usually performed first using NWS weather data. Modeling can also be performed using weather data from other sources, such as weather stations operated by commercial airports or the Automated Weather Data Network (AWDN), which is managed by several universities in the northern plains states. When this publication was written, dispersion modeling had been performed for 5 regions in Nebraska and 2 regions of South Dakota using NWS weather records. Recently, modeling for an additional region in each state was completed using AWDN data (designated with a * in lists below). Consequently, directional setback distances can be determined for the following regions:

Region (weather station location)	Region (weather station location)
Northeast Nebraska (Norfolk, NE)	Southeast South Dakota (Sioux Falls, SD)
Southeast Nebraska (Lincoln, NE)	Western South Dakota (Rapid City, SD)
South-central Nebraska (Grand Island, NE)	Northeast South Dakota (Watertown*, SD)
Southwest Nebraska (North Platte, NE)	
Nebraska panhandle (Scottsbluff, NE)	
North-central Nebraska (Ainsworth*, NE)	

As resources are made available to support performing the required modeling, information will become available to utilize weather data for more localized areas and for other states.

Risk-avoidance level:

Risk avoidance is designated as an 'odor annoyance-free frequency'. The annoyance-free frequency is a very important, required input for the Odor Footprint Tool. The value selected represents the minimum percentage of hours during which a residence situated at or beyond the setback distance should be free from being exposed to annoying levels of odor. Options typically include 90%, 94%, 96%, 98% and 99% annoyance-free frequencies. For 96% odor annoyance-free conditions, for example, odors at locations beyond the specified distance are projected to be at annoying levels less than 4% (100% - 96%) of the time, while within this distance, odors may be at annoying levels more than 4% of the time. Since 1 hour over a period of 4 full days is a frequency of about

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1%, a location at the 96% odor annoyance-free distance is projected to experience annoying odor levels for, on average, no more than 4 hours in a four-day period, which equates to an hour a day or 30 hours a month.

The annoyance-free frequency selected will have a dramatic effect on the resulting separation distance. In most cases, selecting the next-higher odor annoyance-free frequency will increase the separation distance more than does doubling the size of the operation. Selecting 99% (or wanting a higher percentage) may sound desirable, but may be unrealistic for many areas due to the large setback distances that would be required and challenges associated with applying such a high standard in agricultural regions. On the other hand, asking residents to endure annoying odor levels 10% of the time is probably equally unrealistic for most areas if positive neighbor relations are to be maintained. Selection of an annoyance-free frequency is where the vision and values of the given operation and of the surrounding rural community need to be considered and come into play.

Terrain:

The lay of the land around an animal feeding operation affects how and where odors move. Base directional setback distances are representative of sites where the surrounding land is fairly flat to gently rolling. Odorous air may be confined within valleys and will 'drain' downhill under calm conditions. Odorous air will also either go around significantly elevated areas or be dispersed more quickly when moved over higher terrain. Adjustments in separation distances are needed to account for these effects on the frequency of exposure to annoying odor levels. To account for noteworthy topographical effects, terrain factors are employed within the Odor Footprint Tool to increase, decrease or retain the separation distances in certain directions based upon the specified terrain.

Versions:

The Odor Footprint Tool is available to users in worksheet-based and spreadsheet versions. Both versions require the same basic input information and produce minimum separation distances in four directions.

The worksheet-based version of the Odor Footprint Tool involves using a one-page worksheet, a few tables, and one or two sets of four graphs. These materials can be maintained as files on a computer and the worksheet may be completed electronically, or the materials can be printed out and the worksheet may be filled out by hand. While the fastest way to use the Odor Footprint Tool is to use the spreadsheet version, there are a few advantages to using the worksheet-based version. For one, a computer is not required to determine setback distances. Another advantage of completing a worksheet is that it is more obvious where to prioritize control odor on the operation; because going through intuitive steps along the way highlights the contributing sources of odor on an operation more clearly. Those who will regularly use a spreadsheet version of the Odor Footprint Tool are strongly encouraged to first use a worksheet-based version to help them know what information is most useful and more fully utilize results from the spreadsheet version. The University of Nebraska publication *Determining Separation Distances Using the Odor Footprint Tool: User's Manual for the Worksheet-Based Tool* provides step-by-step guidance in utilizing the materials that have been developed for Nebraska regions.

Spreadsheet versions of the Odor Footprint Tool utilize commonly available software (e.g. MS Excel®) to simplify and hasten the process of determining directional setback distances. This timeliness advantage can be especially beneficial when several scenarios are being considered. Since few if any hand calculations are needed, opportunities for calculation errors are also minimized. The University of Nebraska publication *Determining Separation Distances Using the Odor Footprint Tool: User's Manual for the Spreadsheet Tool* provides step-by-step guidance in utilizing the spreadsheet that has been developed for Nebraska regions.

The common element behind the various forms of the Odor Footprint Tool is the procedure developed and utilized at the University of Nebraska – Lincoln to determine separation distances. Other states or organizations

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may adopt this procedure, and modify the presentation of the information to suit their regions. For example, South Dakota State University developed its own spreadsheet called SDOFT (South Dakota Odor Footprint Tool), but the underlying information was produced at the University of Nebraska – Lincoln and in the same way as for Nebraska regions.