

# Siting of Livestock and Poultry Facilities Using MNSET

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**Species:** Swine, Beef, Dairy Poultry  
**Use Area:** Animal Housing and Manure Storage  
**Technology Category:** Facility Siting  
**Air Mitigated Pollutants:** Odor, Hydrogen Sulfide, Ammonia

## Description:

The Minnesota Setback Evaluation Tool (MNSET) is a prediction tool that can be used for quickly evaluating odor, hydrogen sulfide, and ammonia impacts from a feedlot. MNSET combines the original odor impacts predicted using OFFSET with additional dispersion modeling results for hydrogen sulfide and ammonia based on AERMOD, an EPA approved air dispersion model. This original modeling effort began in 2003 with a field validation and calibration of AERMOD on a farm in Iowa (Schmidt et al, 2004). This same model was then used to predict hourly downwind concentrations of hydrogen sulfide from twenty-one case studies (Schmidt et al., 2006). Case farm model inputs included source layout and dimensions, hydrogen sulfide flux rates, along with five consecutive years of historical weather data, 1986 through 1990, at four geographic locations including Minneapolis, Minnesota, Rochester, Minnesota, Fargo, North Dakota, and Sioux Falls, South Dakota. From these results, a statistical model was developed to evaluate downwind concentrations of hydrogen sulfide and the probability that these concentrations would exceed the Minnesota ambient air quality standard for hydrogen sulfide.

MNSET input parameters include source dimensions, flux rates of odor, hydrogen sulfide, and ammonia for the source, the presence of any mitigation technologies and the efficiencies of these technologies. It should be noted that as with any dispersion model, the emission rate (mass of pollutant emitted over time) is the most significant variable affecting downwind concentrations and that these downwind concentrations are linearly related to a specific site emission rate which is in turn related to the size of the emitting source and its flux rate. For instance, at a given receptor location, a 50% reduction in site emissions would result in a 50% reduction in concentration at this receptor.

MNSET estimates three separate outputs. The first estimation is for the frequency of downwind odor impacts. These outputs are based on the original OFFSET work done by Jacobson et al. (2005) and reported by Guo et al. (2005). As in the original OFFSET model, there are no provisions for predominant or prevailing wind direction (setback distances predicted based on direction from the site). The general belief held by the model developers is that worst case odor events occur under relatively low wind conditions and that the directional component of these low wind conditions is not easily determined and hence is not included in any data set of historical weather. As such, the inclusion of wind direction could result in under predicting the frequency of odor events. Figure 1 shows the estimated odor impacts from a 3000 head swine finishing facility in Minnesota.

MNSET also predicts the expected frequency of exceeding the Minnesota Standard for ambient hydrogen sulfide concentration at a specified distance, typically, the nearest property line. As would be expected, these exceedences occur more frequently near the farm and less frequently at distances further from the emission sources (figure 2). Note how

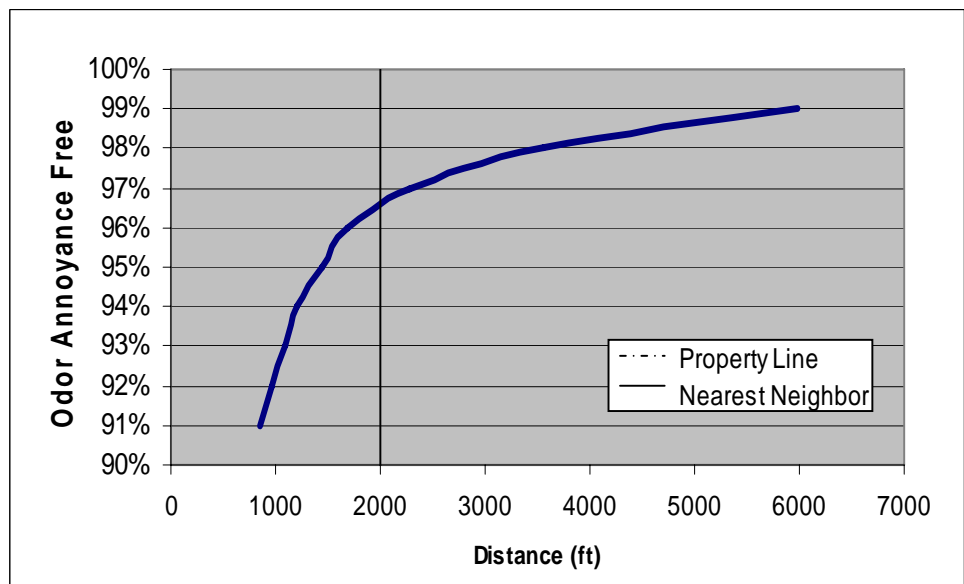


Figure 1. MNSET predicted odor impacts from 3000-head swine finishing building. Nearest neighbor and property line distances are also noted.

quickly the exceedence frequency drops over the first 500-700 feet from the source. This probability curve looks very similar for most sizes of farm sites suggesting that setbacks greater than 1000 feet would likely meet MN state regulatory standards for hydrogen sulfide.

Additionally, MNSET also predicts the daily pollutant load for hydrogen sulfide and ammonia. For the example of the 3000 head swine finishing barn MNSET predicts 3 lbs per day of hydrogen sulfide emissions and 42 lbs per day of ammonia emissions. All MNSET are based on average values for flux rates found in literature. It is likely that future research will better document these flux rates thus improving the model predictions.

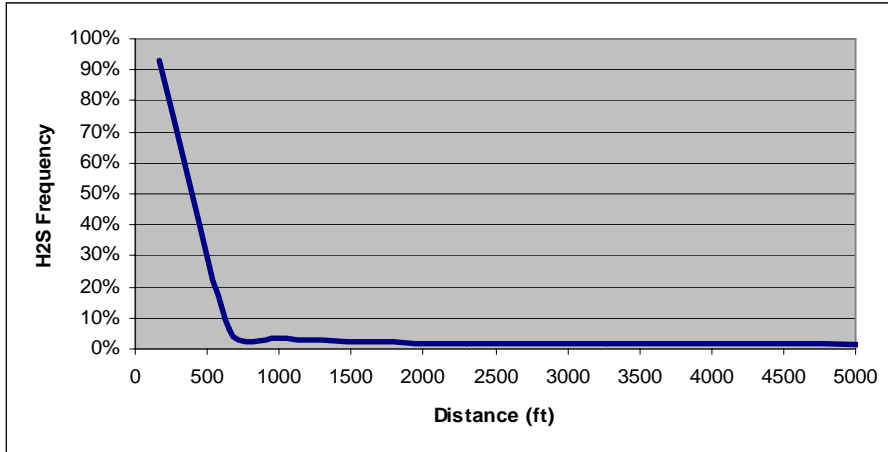


Figure 2. Predicted frequency of exceeding the Minnesota ambient hydrogen sulfide standard.

## Mitigation Mechanism:

MNSET can be used in the siting of new facilities and determining the impacts of mitigation techniques on new or existing facilities.

### New Facilities

Siting of new livestock facilities is often met with opposition related to ambient air quality issues related to odor nuisance or human health. This opposition is not always based on sound science. However, defending the siting location is not always based on sound science either. Site specific dispersion modeling is sometimes done but this can be both expensive and time consuming. MNSET is a viable alternative to site assessment that can be done at little or no cost and completed in a short amount of time.

Simple inputs of types and sizes of buildings, lots, and manure storages into MNSET will result in predicted frequencies of odor impacts at distances from the proposed site. Additions of mitigation technologies to the site will quickly show changes in these odor impacts. This predicted information allows for a more objective discussion about odor nuisance issues. Using these same inputs, MNSET also predicts the frequency of exceeding Minnesota ambient air quality standards for hydrogen sulfide, a gas associated with both nuisance issues and human health concerns. In areas where local concerns are related to nitrogen loading, MNSET can be used to predict annual loading from the proposed site (and reductions of load based on implementation of mitigation techniques.) For instance, model results shown in Figure 1 for a 3000 head swine finishing facility suggest that the proposed location, 2000 feet from the nearest neighbor, will likely result in annoying odor problems approximately 3.5% of the time (96.5% annoying odor free). By moving the site location the neighbor impact could be reduced or increased according to the curve shown. In addition, it is easy to assess the downwind impacts of any proposed mitigation techniques. MNSET has

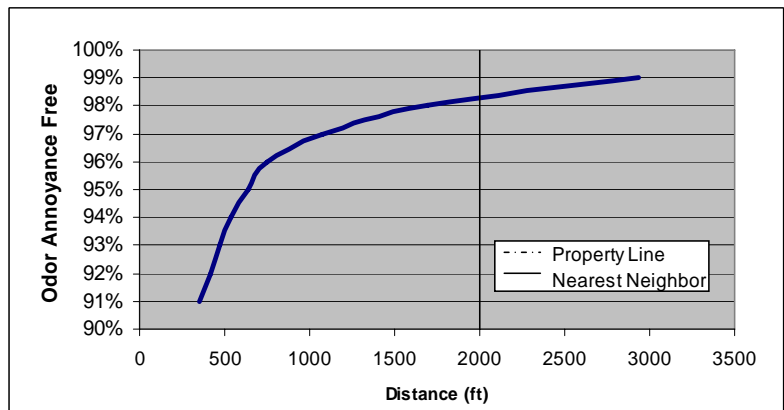


Figure 3. Example output for a 3000-head finishing barn with 75% odor mitigation technology implemented.

built in drop down boxes for several mitigation technologies and allows for additions of other technologies currently not listed in the program. Figure 3 shows the predicted odor impact with the addition of a technology that reduces the site emissions by 75%. With this scenario, MNSET estimates indicate a decrease in odor impacts to the level of less than 2% of the time.

## Existing Sites

MNSET can also be used to evaluate the use of mitigation technologies to solve existing siting issues. Production sites with existing neighbor complaints, or regulatory compliance issues related to air quality, are often willing to implement mitigation technologies if there is 1) some indication that the nuisance or regulatory issue actually exists and 2) if the proposed mitigation technique is likely to resolve this nuisance or regulatory issue. The question might be, "If I implement technology 'X' that provides an estimated 20% reduction in emissions, will this be enough to solve my problem or do I have to implement technology 'Y', a much more expensive technology but reduces emissions by 80%." Site specific dispersion modeling can assess this situation but this situation can also be effectively evaluated with MNSET. Within seconds these technologies options can be assessed for both neighbor and property line impacts. Additionally regulatory compliance issues related to annual pollutant load can also be estimated. Currently, MNSET results are not accepted by regulatory agencies however, efforts are being made to show that MNSET results are likely more restrictive than accepted regulatory models which will enhance the use of MNSET a screening tool for these issues.

## Implementation and Applicability:

Although MNSET was developed specifically for use with Minnesota building types and weather conditions, the model can be used to predict relative impacts from different types of facilities in any geographic location. Flux data (mass/area/time such as grams/second/square meter) from buildings and area sources used in the model are based on the best literature values at the time of model development. These values are not specific to Minnesota and there is little data to show how these values might change geographically across the US or other parts of the world. As such, the default values for the given sources are likely applicable in most situations. However, not all types of emission sources are listed in the model. There are new styles of barns or obscure emission sources (e.g. dead animal composting piles) where no flux data is available. Knowing that this is an issue, MNSET incorporates a feature to allow the user to enter other source types and corresponding flux data as it becomes available. This is also true for mitigation technologies. There are some mitigation technologies listed in the model but the model allows for users to include additional mitigation technologies and corresponding reductions. One caution however, is the need for documenting flux data or mitigation efficiencies for any of the user inputs into the model. For instance there are several mitigation technologies that claim significant reductions and the user would be wise to verify these claims prior to including these reductions in the model results. MNSET allows for this type of documentation.

MNSET predictions for ambient impacts are based on historical Minnesota meteorological data. As such, applying this model for downwind impacts in other geographic regions currently requires some programming changes to the model. These changes have been done for several states for the original version of OFFSET and involve determining frequencies of wind speed and stability classes for these areas. Without this information, MNSET results for downwind impacts are only reliable in Minnesota. However, other geographic regions can still use MNSET for site comparisons and "what if" scenarios. Downwind impacts for neighboring states will likely be very similar to what is predicted for Minnesota.

## Cost:

MNSET is an EXCEL spreadsheet model and is available free on-line at [www.manure.umn.edu](http://www.manure.umn.edu) then click on "Air Quality." The use of MNSET to quickly evaluate and compare the impacts of various technologies will also save time and money on siting decisions and decisions related to choosing the appropriate mitigation technology.

## Technology Summary:

MNSET predicts three separate values. The first prediction is for odor impacts at any given distance downwind from the facilities. The second prediction is for the frequency of exceeding the MN state standard for hydrogen sulfide. Although this may not be applicable for other states it does show relative impacts of hydrogen sulfide. Additionally, MNSET estimates both daily and annual pounds of hydrogen sulfide and ammonia emitted from the modeled facility. Remember however that the outputs of the models are only as valid as the inputs. A literature review was done to develop the flux values used in the model.

## Additional Resources:

Please visit [www.manure.umn.edu](http://www.manure.umn.edu) for more information on MNSET.

## References

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