Setbacks of CFO/CAFO Manure Lagoons and Land Application of Manure to Protect Public Health in Rural Communities

CFO Rulemaking Discussion Paper

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EXECUTIVE SUMMARY

Estimates show that livestock housed on Concentrated Animal Feeding Operations (CAFOs) generate approximately 300 million tons of manure every year, roughly twice the total manure generated by the U.S. human population. For residents who live near concentrations of this waste, the impacts to air and water quality can render the rural countryside nearly uninhabitable. And because proximity to manure lagoons drastically reduces property values, these residents are often trapped with these conditions.

Air emissions from manure lagoons and land application of manure can cause serious and chronic respiratory problems. The odor of manure can dramatically decrease quality of life and alter the psychological condition of neighbors. High concentrations of hydrogen sulfide and ammonia can slowly poison local residents and cause chronic neurological and respiratory problems.

Water emissions also pose a serious risk to the health of rural residents. High levels of E. coli and other fecal pathogens can invade groundwater and surface water when manure is improperly managed, leading to local outbreaks of these infections. Well-water resources and other drinking water sources can become compromised with pathogens or nitrates, which can also cause debilitating and even deadly disease outbreaks.

Grand Lake St. Marys
Even if manure is properly managed to minimize air and water emissions, proximity to the CAFO, workers, and animal carcasses can still spread disease. The likelihood of contracting a livestock-related pathogen or infection is much higher in the countryside, leading to statistically higher incidence rates of MRSA and other diseases in rural areas.

As the State Chemist of Indiana and the Indiana Department of Environmental Management develop new rules with regards to the storage, use, and distribution of manure the potential risks to rural residents must be taken into consideration. It is the duty of these entities to protect the waters of the state and the health of the general public by writing rules that will incorporate proper biosecurity and treatment to minimize the risk of air and water pollution from CAFOs.

Contamination can be avoided with best management practices. Simple steps such as proper composting and anaerobic digestion can minimize pathogen content. Vegetated buffer strips can prevent most water pollution, and covering manure lagoons or investing in anaerobic digestion can prevent air emissions. However, reducing the proximity of rural residents and water resources to untreated manure is the easiest and least expensive management practice. By incorporating stronger setbacks and other best management practices into the rules, the State Chemist and the Indiana Department of Environmental Management can prevent public health problems from improper handling or exposure to livestock manure.

CFO/CAFO RULEMAKING DISCUSSION PAPER

TOPIC: Setbacks of CFO/CAFO manure lagoons and land application to protect public health in rural communities

OVERVIEW OF ISSUES

Because of the large scale of livestock feeding operations, proper manure management is critical to the health of rural residents. Every year, more than 335 million tons of "dry matter" waste are produced, stored, and distributed by U.S. farms.[1] 2,500 cows on a single dairy farm generate roughly the same amount of manure as 411,000 humans.[2] In a state like Indiana, with more than 2,000 CFOs, proper handling of this vast quantity of manure is even more crucial. While the manure generated by humans is treated, the manure generated by livestock on CFOs and CAFOs is often left untreated and allowed to degrade into an anaerobic state, giving off noxious and hazardous air emissions.[3]

In this discussion paper we raise three issues regarding the potential health impacts of manure management and the duty of IDEM and the State Chemist to protect Indiana's environmental and public health: (1) what potential health risks are associated with air pollution from manure in uncovered storage facilities and manure when land applied; (2) what potential health risks are associated with water pollution from manure in storage facilities and manure when land applied; and (3) how regulatory bodies can ensure that these public health risks are minimized.

Air Pollutants Associated with Livestock Manure

Odor from manure might seem a minor annoyance, but there are numerous problems associated with regular exposure to the smell emanating from manure lagoons and land application sites. Studies have revealed that residents living near manure storage facilities or land applications sites often experience psychological problems such as anxiety, depression, and other mood disorders, as well as frequent sleeping problems.[4] Odor issues also decrease property values,[5] making it difficult or even impossible for rural residents to escape from these conditions.

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[1] USDA Agricultural Research Service. *"FY-2005 Annual Report Manure and Byproduct Utilization,"* May 2006.
[2] US Environmental Protection Agency. "Risk Management Evaluation for Concentrated Animal Feeding Operations." US EPA National Risk Management Laboratory. May 2004.
[3] Iowa State University and The University of Iowa Study Group, "Iowa Concentrated Animal Feeding Operations Air Quality Study," February 2002.
[4] Studies conducted by Schiffman et al. (1995, 2000), quoted in "Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operations"
[5] Studies conducted by Abeles-Allison and Conner (1990); Hamed et. al. (1999); Herriges et al. (2003); Palmquist et al. (1997), quoted in "Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operations"

While noxious odor is one obvious air pollution problem associated with animal feeding operations, there are more dangerous air pollutants that are expelled by the manure when it sits in an anaerobic pond or is applied to farmland. The main pollutants are:[6]

- Gases:
  - Hydrogen Sulfide (H_2S)
  - Ammonia (NH_3)
  - Methane (CH_4)
  - Nitrous Oxide (N_2O)
  - Nitric Oxide (NO)
- Volatile Organic Compounds (VOCs)
- Particulate Matter (PM)

Hydrogen Sulfide

Hydrogen sulfide is a cyanide-like gas which is reported to smell like rotten eggs. H_2S prevents cells from using oxygen, which can lead to problems associated with asphyxiation such as loss of consciousness, comas, or even death in cases of high-level exposure.[7] Exposure to higher levels of H_2S can cause numerous and severe health problems. Acute toxicity can damage the respiratory, cardiovascular, neurological, and immune systems.[8]

Ammonia

Ammonia inhibits the cilia in the lungs from properly removing dust. Because ammonia has the potential to bond with dust particles, it is a particularly dangerous gas for residents living near manure storage facilities and land application sites.[9] Short-term and long-term exposure to low levels of ammonia can cause irritation and pain in the eyes, nose, and throat. Exposure to high levels of ammonia can kill in less than 30 minutes.[10]

Methane

Methane is an asphyxiant gas. While high levels of methane can kill, it generally will only cause asphyxiation within a closed environment by replacing air.[11] Methane can be dangerous in closed environments due to its highly combustible nature, but most residents will be affected by the odor and the contributions to climate change.

Enteric fermentation and manure management were responsible for 185.8 of the U.S. total 567.6 natural source TgCO2 equivalents in 2008.[12] With a greenhouse potential twenty-three times

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[6] Ad Hoc Committee on Air Emissions from Animal Feeding Operations, Committee on Animal Nutrition, National Research Council, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*, National Academies Press, 2003.
[7] Institute for Agriculture and Trade Policy, "CAFOs:Health Risks from Air Pollution," October 2004.
[8] Ad Hoc Committee on Air Emissions from Animal Feeding Operations, Committee on Animal Nutrition, National Research Council, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*, National Academies Press, 2003.
[9] Institute for Agriculture and Trade Policy, "CAFOs:Health Risks from Air Pollution," October 2004.
[10] Ad Hoc Committee on Air Emissions from Animal Feeding Operations, Committee on Animal Nutrition, National Research Council, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*, National Academies Press, 2003.
[11] Boc Gases, "Materials Safety Data Sheet," June 7, 1996.
[12] *Methane and Nitrous Oxide Emissions from Natural Sources*, EPA, April 2010.

greater than CO_2 and the ability to spread through the atmosphere, excess methane emissions are not a localized problem like odor, some of the other gases, PM, and VOCs.

Nitrous and Nitric Oxide

Nitrous oxide and Nitric oxide are also greenhouse gases, and primarily affect air quality as such. Agricultural soil management and manure management account for 233 of the U.S. total 318.2 natural source TgCO2 equivalents in 2008.[13] NO_2 and NO can interconvert in the atmosphere to create NO_x, a contributor to acid rain which can further oxidize or incorporate with other atmospheric gases. NO_x can impact tropospheric ozone (O_3) production, aid in the formation of dangerous fine particles ($PM_{2.5}$) and ozone pollution that may cause respiratory illness or other human health problems such as:[14]

- Decreases in lung function
  - Difficulty breathing
  - Shortness of breath
  - Other symptoms
- Respiratory symptoms
  - Bronchitis
  - Aggravated coughing
  - Chest pain
- Increased incidence/severity of respiratory problems
  - Aggravation of asthma
  - Susceptibility to respiratory infection
- Chronic inflammation and irreversible structural changes in the lungs that, with repeated exposure, can lead to premature aging of the lungs and other respiratory illness.

Volatile Organic Compounds

VOCs are one of the primary causes of manure smell and odor-related maladies. The most prevalent VOC emissions from livestock manure are organic sulfides, disulfides, C4 to C7 aldehydes, trimethylamine, C4 amines, quinoline, dimethylpyrazine, and C3 to C6 organic acids, along with lesser amounts of aromatic compounds and C4 to C7 alcohols, ketones, and aliphatic hydrocarbons.[15] The impact of VOCs on local residents is cumulative; residents exposed to regularly high levels of VOCs experience mild to major irritation and can develop systemic responses, such as changes in respiratory function.[16]

Particulate Matter

Particulate pollution invades the respiratory system and can often reduce respiratory function. Typically, the over-exposure to particulates in humans results in an increased risk of cardiovascular, respiratory diseases, and lung cancer.[17] The most common particulate pollution generated by livestock operations are fecal matter, fur, feathers, and dust. Of greatest concern to

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[13] *Methane and Nitrous Oxide Emissions from Natural Sources*, EPA, April 2010.
[14] "Reactive Nitrogen in the Environment," United Nations Environment Programme and Woods Hole Research Center, 2007.
[15] Ad Hoc Committee on Air Emissions from Animal Feeding Operations, Committee on Animal Nutrition, National Research Council, *Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*, National Academies Press, 2003.
[16] Schiffman et al. "Health Effects of Aerial Emissions from Animal Production and Waste Management Systems," National Center for Manure and Animal Waste Management, White paper summaries.
[17] "Air Quality and Health," World Health Organization, August 2008.

local residents are the fecal particles. Exposure to PM from livestock manure can cause a multitude of health risks. Pathogens, particularly fecal coliformes such as E. coli and Salmonella, can be transmitted to local residents via airborne PM when manure is land-applied without treatment. These pathogens can then also contaminate local water supplies if soil management and erosion prevention methods are not successfully utilized. [18]

Other chronic respiratory ailments are often associated with proximity to CFOs and CAFOs but have not been narrowed to a specific pollutant. Some of the disorders prevalent near swine operations include: [19]

- Upper airway disease
  - Sinusitis
  - Irritant rhinitis
  - Allergic rhinitis
  - Pharyngitis
- Interstitial disease
  - Alveolitis
  - Chronic interstitial infiltrate
  - Pulmonary edema
- Lower airway disease
  - Organic dust toxic syndrome
  - Occupational asthma
    - Nonallergic asthma,
      - hyperresponsive airway
      - disease, or reactive
      - airways disease syndrome
    - Allergic asthma (IgE mediated)
- Acute subacute bronchitis
- Chronic bronchitis
- Chronic obstructive pulmonary disease

In addition, the prevalence of physician-diagnosed asthma in school-age children rises in areas proximal to CAFOs. [20] While other factors, such as the percentage of parents that smoke or the presence of pets, contribute to this problem the air emissions from CAFOs are very likely to be a major contributor to chronic respiratory disorders in young children.

These chronic respiratory disorders result from regular exposure to manure odors and air pollutants. Rural residents who suffer from these problems often have to visit hospitals more frequently, require costly medical care and medical procedures that would not otherwise have been necessary, and endure a lower quality of life and poor health because of the proximity of livestock manure.

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[18] Graham, Jay P. et al, "The Animal-Human Interface and Infectious Disease in Industrial Food Animal Production," Public Health Reports, May–June 2008, Volume 123.
[19] Results published by Donham, KJ 2000, quoted in "Addressing Externalities From Swine Production to Reduce Public Health and Environmental Impacts"
[20] Sigurdarson, Sigurdur T. and Joel N. Kline, "School Proximity to Concentrated Animal Feeding Operations and Prevalence of Asthma in Students," American College of Chest Physicians, 2006.

Water Pollutants Associated with Livestock Manure

There are many variables that must be incorporated into proper manure management plans and nutrient management plans in order to mitigate water pollution and nutrient overloading. Untreated manure can contaminate groundwater, surface water, and wells through multiple pathways: [21]

- Poorly constructed manure lagoons;
- Major precipitation events, flooding, or overflow of manure lagoons;
- Recent application of manure to fields; and
- Atmospheric deposition followed by dry or wet fallout.

The extent to which manure impacts water quality is likewise determined by multiple factors: [22]

- Proximity to water resources;
- Soil properties;
- Contaminant properties;
- Hydraulic loading characteristics; and
- Crop management practices.

All of these factors must be calculated when designing effective management plans, but the most important and easily controlled factor is proximity. If lagoons and land application sites are located far from water bodies and/or the pathway to water bodies is impeded by a heavily vegetated buffer strip, the chances of contamination are substantially reduced.

In the draft version of the 2010 Indiana impaired waters list, 822 water bodies were listed as impaired for E. coli. This is a strong indication that untreated manure is contaminating the waters of the state. Though pathogen contamination can come from various sources, livestock manure is a major contributor. This manure can make its way into our waterways through multiple points: spills from manure storage facilities; spills during transportation and land application; spills from staging locations; and agricultural storm water runoff after manure land application.

Spills from Manure Storage Facilities

When manure storage facilities or lagoons are improperly constructed or allowed to fall into disrepair, manure and contaminants can leech out of the lagoon and into the soil, threatening groundwater and surface water resources. The Centers for Disease Control tested manure in lagoons as well as agricultural drainage wells, tile line inlets and outlets, monitoring wells, underground water, and one river near nine CAFOs in Iowa. Chemical pollutants, pathogens, heavy metals, bacteria, parasites, and high levels of nitrates were found in all of these sites. In addition, earthen lagoons were shown to contain the highest levels of these contaminates. The study results showed that pollutants can move through the soil and contaminate nearby water resources. [23]

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[21] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[22] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[23] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.

During times of high rain, there is an additional risk to water from flooding. Extensive rains can cause lagoons to overflow if they are not covered or otherwise protected from the elements. Other environmental catastrophes, such as hurricanes and tornadoes, can exacerbate these flooding problems. In 1999, when North Carolina was struck by Hurricane Floyd, at least five manure lagoons completely burst and at least 47 other lagoons were so badly flooded that manure freely flowed out of the storage sites along with the flood waters.[24]

Even without the added pressure of uncontrollable weather conditions, manure lagoons often regularly leech nutrients and pathogens into groundwater and drinking water resources. Groundwater attained from private, and usually untreated, wells supply roughly 42 million Americans with drinking water resources. [25] These wells can easily become contaminated by manure leeching. In Iowa, a representative sample of CAFO lagoons revealed that 18% were sited atop alluvial aquifers. [26] These aquifers are the most common source of drinking water, and are particularly vulnerable to contamination. Manure lagoons constructed below the water table also increase the likelihood of leeching and overflowing, further threatening water quality and human health.

Unfortunately, there are also some CAFO operators and/or landowners that deliberately release manure from storage lagoons rather than properly disposing of it. Most recently, the defunct Muncie Sow Unit lagoon dike was damaged by the new property owners and roughly four and a half million gallons of manure flooded the Mississinewa River. [27] Incidents such as this are fortunately rare; however, IDEM reported nearly 40 manure and animal waste spills in 2008 alone, [28] illustrating the need for further water quality protections.

Spills from Staging Locations

Manure that is staged poses an even greater threat to water quality. While manure lagoons offer some protection from the elements and enclosure to prevent leakage and runoff, most staging locations are completely exposed. If manure is staged near waterways, especially in times of flooding and/or excessive rain, there is a great risk that the manure will contaminate ditches and soil, spreading to the waters of the state or even to groundwater and drinking water resources. Specific rules and best management practices for staged manure have been set forth by IDEM. For manure that is staged for more than 72 hours, the applicator or CAFO operator must: [29]

- Must be land applied to the site within 90 days of staging;
- Effectively cover or berm; and
- Stage manure in an area:
    - With a slope less than six percent;
    - Does not have standing water;
    - Not within 300 feet of an intermittent waterway; and

[24] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[25] "Concentrated Animal Feeding Operations: Health Risks from Water Pollution," Institute for Agriculture and Trade Policy, August 2004.
[26] "Concentrated Animal Feeding Operations: Health Risks from Water Pollution," Institute for Agriculture and Trade Policy, August 2004.
[27] "Manure Spill May Have Been Deliberate," Manure Manager Magazine, May 14, 2009.
[28] IDEM Emergency Response Spills Data, Agricultural-source reports of manure and animal waste.
[29] "Solid Manure Staging," Indiana Department of Environmental Management, November 10, 2008.

- Not within 300 feet of waters of the state.

These rules are designed to prevent run-off from the staged manure. In addition, best management practices must be incorporated to ensure the efficancy of these rules; most importantly, landowners and applicators must pay attention to weather forecasts prior to manure application to ensure that runoff is prevented. [30]

If these rules are properly enforced, they will prove effective at preventing manure contamination from staging sites. They do not, however, address the issue of air emissions. At this time, IDEM does not regulate odor and gases from manure. It is suggested that CAFO operators and applicators "have consideration" for nearby homes and schools, [31] but given the potential health risks of exposure to air emissions, it is crucial that IDEM address air pollution of staged manure as well as the water contamination.

Agricultural Storm Water Runoff

While the use of manure as a fertilizer can provide better nutrient content to the soil than chemical fertilizers, improper application or over-application of manure is prevalent. This misuse of manure can cause excessive runoff from fields where manure has been land applied.

Macronutrients such as phosphorus and nitrogen and micronutrients such as heavy metals cannot be effectively absorbed by the soil when plant life is not present. The application of manure to soils when crops are not growing is a major contributor to runoff. [32] Because of the amount of manure generated by CAFOs, fields are often fertilized when manure lagoons need to be emptied rather than when crops require nutrients. In particular, application of manure in late fall and throughout the winter, when soil is mostly frozen, results in the runoff of nearly all manure applied when the soil thaws. [33]

The oversaturation of soils is the other primary cause of runoff. Even if manure applicators comply with the recommended rates of application, if soil has already been oversaturated the nutrients will leech through the soil to aquifers or run off into nearby water bodies. [34] Every crop requires different nutrient levels; application of more nutrients than needed by crop cover usually results in runoff of most excess nutrients. [35] Other contaminants from untreated manure, such as pathogens, antibiotics, growth hormones, other pharmaceuticals, and heavy metals, travel with nutrients into waterways. [36] These other contaminants often pose an even greater risk to drinking water resources and, therefore, human health than excessive nutrients.

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[30] "Solid Manure Staging," Indiana Department of Environmental Management, November 10, 2008.
[31] "Solid Manure Staging," Indiana Department of Environmental Management, November 10, 2008.
[32] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[33] "Winter manure application," Iowa Manure Manager Series, Volume 3, Iowa Manure Management Action Group, Iowa State University, December 2006.
[34] Studies conducted by Westerman et al. (1995); Stone et al. (1995); Evans et al. (1984); Ham and DeSutter (2000); Huffman and Westerman (1995), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"
[35] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[36] Studies conducted by Barker and Zublena (1995) and Karr et al. (2001), quoted in *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*

The two most common pollutants are nitrogen and phosphorus. Phosphorus is less soluble in the soil, and so it is often carried directly to waterways through agricultural stormwater runoff. Excess phosphorus can dissolve in soils before running into water bodies, leading to a high concentration of dissolved phosphorus in surface waters. [37] Nitrogen generally leeches through the soil, posing a threat to aquifers and groundwater as well as surface water. Because nitrogen often moves through the soil it is a particularly insidious pollutant; vegetative buffers will not be effective at stopping excess nitrogen from contaminating drinking water sources. [38]

These two nutrients, when present in high amounts, are the primary contributor to blooms of cyanobacteria, or blue-green algae. This form of algae produces cyanotoxins that harm human health and contribute to eutrophication of lakes, rivers, and streams. The runoff and leaching of these nutrients contributes roughly fifteen percent of the total excess nutrient pollution that causes the Gulf "dead zone," a large area of water where the Mississippi River reaches the Gulf of Mexico in which fish and commercially-viable aquatic life are now unable to survive. Other estuaries along the East Coast, such as the Chesapeake Bay, face similar problems with eutrophication. [39]

Agricultural storm-water run-off from fields where manure has been applied but not incorporated has been proven to contaminate Indiana waterways. On June 19, 2010, agricultural run-off in Randolph County resulted in a massive fish kill; more than 100,000 fish died in the Mississinewa River and Bear Creek, one of its tributaries. IDEM inspectors have already determined that the cause was a local pork producer, who sprayed roughly 200,000 gallons of untreated hog manure on a 60-acre field upstream of the fish kill, [40] without a permit to discharge manure, and failed to report or manage the spill. Manure spills such as this can be prevented by incorporating more stringent regulations on the storage and land application of manure.

Public Health Risks of Manure Spills

There are multiple health risks associated with manure spills and nutrient leaching. The contamination of drinking water resources and exposure to algal blooms and pathogens render many Indiana waterways unsafe for human interaction. The primary contaminants that pose health risks to human populations are: pathogens, pharmaceudicals, nitrates, and algal blooms.

PATHOGENS

Livestock operations in the United States create more than 300 million tons of manure every year; and unlike human waste, this waste is not treated. [41] The lack of proper treatment of livestock waste leads to the proliferation of pathogens, which can contaminate crops and

[37] Gurian-Sherman, Doug, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, Union of Concerned Scientists, April 2008.
[38] Gurian-Sherman, Doug, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, Union of Concerned Scientists, April 2008.
[39] Gurian-Sherman, Doug, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, Union of Concerned Scientists, April 2008.
[40] Incident Report, State Form 13490, IDEM, Emergency Response, June 21, 2010.
[41] Graham, Jay P. et al, "The Animal-Human Interface and Infectious Disease in Industrial Food Animal Production," Public Health Reports, May–June 2008, Volume 123.

drinking water resources. Pathogens in manure can survive long periods of time in lagoons and soils; viruses can survive for up to six months and bacteria can survive for up to a year. [42]

Infectious organisms contaminate water, but they can also pass into human populations via workers on the CAFO. Improper handling of animals and/or manure can lead to outbreaks. The pathogens that pose the most common risks to human health are:

- ***E. Coli***
  Found in the intestines and feces of all mammals, E. coli is particularly virulent. [43] E. coli and other fecal coliforms are common problems when working with untreated manure, and have been shown to contaminate crops when proper manure management plans are not implemented. E. coli usually contaminates waterways in times of high rain or flooding, but contamination from faulty or leaking manure lagoons or over-application of manure can contaminate waterways and crops during dry weather periods. Testing conducted by the U.S. Fish and Wildlife Service revealed unsafe levels of fecal coliforms and fecal streptocolli on fields where manure was applied. [44] Studies have shown that dangerous levels of E. coli and other fecal coliforms remain in waterways for at least 61 days after the initial spill, showing that the effects of a single manure spill on the human population can last months. [45]
- ***Cryptosporidium***
  Cryptosporidium is a dangerous pathogen because of its natural resistance to treatment. Common symptoms include diarrhea, vomiting, stomach cramps, and fever lasting several days. In patients with compromised immune systems, however, Cryptosporidium can be deadly. Six reported outbreaks of cryptosporidiosis from drinking water have been linked to manure contamination. [46] In 1993, an outbreak of Cryptosporidium in Milwaukee linked to cattle manure and/or slaughterhouses upstream of the city struck 400,000 persons ill, resulting in nearly $37 million in lost wages and productivity. [47] Ten swine farms in Canada were tested for Cryptosporidium; forty-four percent of the samples from liquid swine manure storage structures, surface drain water, and subsurface tile drainage water came back positive for the parasite. [48]
- ***Methicillin-resistant staphocaucus aureus (MRSA)***
  MRSA is one of the biggest threats to arise from CAFOs. Both human medicine and animal agriculture can contribute to the rise of antibiotic-resistant infections, but an estimated 70 percent of antibiotics produced in this country are used on livestock for these non-therapeutic purposes. [49] While human misuse of antibiotics is a contriubutor, studies indicate that hog farms are a source

[42] Graham, Jay P. et al, "The Animal-Human Interface and Infectious Disease in Industrial Food Animal Production," Public Health Reports, May–June 2008, Volume 123.
[43] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[44] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[45] Studies conducted by Michael Mallin and JoAnn Burkholder, quoted in "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health"
[46] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[47] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[48] Marks, Robbin, "Cesspools of Shame: How Factory Farm Lagoons and Sprayfields Threaten Environmental and Public Health," NRDC and the Clean Water Network, 2001.
[49] "The Hidden Cost of CAFOs: Smart Choices for U.S. Food Production," Union of Concerned Scientists, September 2008.

of a new strain (ST398) of MRSA.[50] MRSA is usually transmitted to the human population through improper manure handling by workers; however, if it is present in manure or animal carcasses that contaminate water resources and/or soil, it can be passed to human populations via food or water resources.

NITRATES

While nitrates are essential components in fertilizer, high levels can hurt humans. The U.S. EPA has set the safe drinking water standard for 10mg/L, one mg/L lower than the World Health Organization (WHO) guidelines. Nitrate levels that exceed safe standards can cause a multitude of health problems:

- Methemoglobinemia (blue-baby syndrome) in infants under 6 months of age;[51]
- Increased risk of hyperthyroidism;[52]
- Increased risk of insulin-dependent diabetes;[53]
- Increased risks for adverse reproductive outcomes;
  - Central nervous system malformations;[54]
  - Neural tube defects;[55]
- Increased risk of cancers of the nasopharynx,[56] prostate,[57] colon,[58] uterus,[59] and brain;[60]
- Possible increased risk of cancers of the stomach, bladder, and esophagus;[61] and
- Possible increased risk of non-Hodgkin lymphoma.[62]

With so many potentially deadly health risks associated with excess nitrates in drinking water, scientifically-recommended nutrient loads need to be incorporated into nutrient management plans to mitigate the impact on rural residents.

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[50] "Putting Meat on the Table: Industrial Farm Animal Production in America," Pew Charitable Trusts and Johns Hopkins Bloomberg School of Public Health, April 2008.

[51] Studies conducted by Ward et al. (2005), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[52] Studies conducted by Seffner (1995) and Tajtakova et al. (2006), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[53] Studies conducted by Kostraba et al. (1992); Parslow et al. (1997); van Maanen et al. (2000), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[54] Studies conducted by Arbuckle et al. (1988), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[55] Studies conducted by Brender et al. (2004); Croen et al. (2001), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[56] Studies conducted by Cantor (1997), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[57] Studies conducted by Cantor (1997), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[58] Studies conducted by De Roos et al. (2003), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[59] Studies conducted by Jensen (1982; Thouez et al. (1981), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[60] Studies conducted by Barrett et al. (1998), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[61] Studies conducted by Cuello et al. (1976); Rademacher et al. (1992); Yang et al. (1998); Barrett et al. (1998); Cantor (1997); Eicholzer and Gutzwiller (1990); Morales-Suarez-Varela et al. (1993, 1995), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

[62] Studies conducted by Ward et al. (1996); Jensen (1982); Weisenburger (1993), quoted in "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality"

PHARMACEUTICALS

Like pathogens, pharmaceuticals can contaminate drinking water resources via manure application or spills from manure lagoons. Growth hormones and antibiotics fed to animals can infect humans exposed to manure and cause complications with other medications. These pharmaceuticals can linger in original composition or degrade in manure during prolonged storage. [63]

ALGAL BLOOMS

Massive blooms of blue-green algae have resulted from the over-application of nutrients to Indiana's farmland. Unlike desirable algae species such as diatoms, noxious and toxic species such as blue-green algae are not digestible. [64] Rather than providing food for aquatic life, this form of algae absorbs nutrients and dissolved oxygen, causing fish kills.

While blue-green algae causes taste and odor issues with drinking water, [65] it is more dangerous because of the production of cyanotoxins. Cyanotoxins are excreted by most of the species of cyanobacteria; however, it is difficult to determine which species produces which toxin given that most species produce multiple toxins and many species bloom together. Known toxins include:

- Dermatoxins (skin irritation);
- Hepatotoxins (liver damage); and
- Neurotoxins (nervous system damage).

The neurotoxins and hepatotoxins produced by some species of cyanobacteria are strong enough to kill fish and small animals, such as dogs. Unless humans are exposed to exceptionally high levels and/or long-term contamination, these cyanotoxins will most likely only cause illness rather than death.

The potential impact of manure from the Grand Lake St. Marys watershed underscores the necessity of more stringent setbacks from waterways. 80% of the Grand Lake watershed acreage is farmland; 20,600 beef and dairy cattle, 80,000 hogs, 168,000 turkeys, and 3.75 million chickens are raised in confined feedlots within this watershed. Altogether, these livestock operations produce 629,504 tons of manure every year. [66] Over the years, the lake has become increasingly enriched by phosphates and nitrates from a number of man-made and natural sources. These nutrients have contributed to the decline of the lake's water quality. [67] 90% of the chicken manure and 75% of turkey manure, an estimated 90,000 tons in 2008, is sold out of state and exported by poultry litter brokers. The remaining hog and dairy manure generally remains in the watershed; shipping is too costly.

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[63] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[64] Burkholder, Joann et al., "Impacts of Waste from Concentrated Animal Feeding Operations on Water Quality," Environmental Health Perspectives, Volume 115, Number 2, February 2007.
[65] Tedesco, Lenore, "Blue-Green Algae Overview," presented at the Blue-Green Algae Symposium, June 17, 2010.
[66] Data taken from Division of Surface Water Geographic Information Systems, Ohio EPA, and Ohio Department of Agriculture.
[67] "State Actions for Water Quality Improvement at Grand Lake St. Marys," Ohio Department of Public Health, Ohio EPA, Ohio DNR, and Ohio Department of Agriculture, July 30, 2010.

In order to effectively utilize the nutrients this manure will have to be spread on 46,000-48,000 acres that need nourishment. The Grand Lake watershed contains roughly 46,000-48,000 crop acres, but the soils are oversaturated with decades of manure and commercial fertilizers and do not need more nutrients. Ohio is proposing to ship the remaining manure out of the watershed as part of the water quality remediation plan; [68] Indiana will likely receive most of this manure as the nearest neighbor. We need stronger water protections in place to keep this manure from contaminating our rivers and lakes the way it contaminated Grand Lake.

Because of the multitude of potential risks to public health from direct and indirect exposure to manure, the contamination of waterways from untreated manure should be carefully monitored and prevented. Like the health risks associated with air emissions from CAFOs, water pollution can cause costly medical care and medical procedures that would not otherwise have been necessary and reduce the quality of life of rural residents.

Recommended Regulations

Proximity to untreated manure instigates a plethora of diseases and disorders, including asthma, anti-biotic resistant diseases, and even cancer. Manure lagoons and land application are not simply an odor issue; the gases, particulates, and runoff of this manure have the potential to debilitate local residents.

It has been shown that people living near CAFOs, particularly swine CAFOs, face a higher risk of specific diseases associated with the livestock manure. Respiratory illnesses, gastrointestinal illnesses, and other adverse reactions suffered by CAFO workers and nearby homeowners can be significant even at distances of two to three miles from CAFOs. [69]

Pathogens can also travel miles from the CAFO and pose public health risks to rural residents. Mycoplasma hyopneumoniae transmission can span 4.5 kilometers (2.8 miles), porcine reproductive and respiratory syndrome (PRRS) virus can travel 4.5 km (2.8 miles), pseudorabies virus can travel 9 km (5.6 mi), and some strains of foot-and-mouth disease (FMD) can travel up to 20 km (12.4 mi). [70] Some strains of Staphocaucus aureus have been found up to 150 m downwind from swine operations. [71] Because of the distances these pathogens can travel, strong setbacks for homes, schools, and hospitals from CAFOs are essential to protect rural communities.

Because of these health risks, the Indiana Department of Environmental Management and the Indiana State Chemist must adopt rules that will protect rural residents from the effects of untreated manure. As previously mentioned, proximity is the factor that can be altered most

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[68] "State Actions for Water Quality Improvement at Grand Lake St. Marys," Ohio Department of Public Health, Ohio EPA, Ohio DNR, and Ohio Department of Agriculture, July 30, 2010.

[69] Studies conducted by Donham et al. 2007; Wing and Wolf 2000; Thu et al. 1997; Wing and Wolf 2000, quoted in Gurian-Sherman, Doug, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, Union of Concerned Scientists, April 2008.

[70] *Good Practices for Biosecurity in the Pig Sector: Issues and Options in Developing and Transition Countries*, Food and Agriculture Organizations, Animal Production and Health Paper No. 169, Rome, 2010.

[71] Studies conducted by Green et al. 2006, quoted in Gurian-Sherman, Doug, *CAFOs Uncovered: The Untold Costs of Confined Animal Feeding Operations*, Union of Concerned Scientists, April 2008.

easily and with the least expense. Incorporating strong setbacks for manure lagoons and manure land application is, therefore, the best way to address these hazards to public health. All future manure storage facilities should adhere to the below setbacks. And because manure lagoons will need to meet new leakage rates and design standards, when these storage facilities are rebuilt they should also be strategically located to adhere to the below setbacks.

There is precedent in Indiana for strong setbacks; twenty-eight counties have adopted local health and/or zoning ordinances to address manure storage and distribution. Of these ordinances, St. Joseph County is one of the few counties to adopt a strong ordinance specifically designed to protect public health. It is the recommendation of the Hoosier Environmental Council that the Indiana Department of Environmental Management and the Indiana State Chemist incorporate the setbacks established in this ordinance: [72]

Residential, RZD, and Municipality Setbacks (in feet)

Number of animal units (au)	Residential		RZD		Municipality	
	Reduced	Standard	Reduced	Standard	Reduced	Standard
1000 -1999	800	1000	1600	2000	3200	4000
2000-2999	1100	1380	2200	2760	4400	5520
3000-3999	1400	1750	2800	3500	5600	7000
4000-4999	1700	2130	3400	4260	6800	8500
5000-5999	2000	2500	4000	5000	8000	10000
6000-6999	2300	2880	4600	5760	9200	10560
7000-7999	2600	3250	5200	6500	10400	10560
8000-8999	2900	3480	5800	6960	10560	10560
9000-9999	3200	3480	6400	7680	10560	10560

* Setbacks for facilities beyond 9999 au are calculated up to the caps: 5280 for residential and 10560 for RZD and municipalities.
*Reduced setbacks apply only to CAFOs that meet strict standards to minimize air and water pollution.

Default Setbacks (in feet)

Number of animal units (au)	Residential Separation Distance	RZD Separation Distance	Municipality Separation Distance
1000 -1999	1320	2640	5280
2000-2999	1590	3180	6360
3000-3999	1860	3720	7440
4000-4999	2130	4260	8520
5000-5999	2400	4800	9600
6000-6999	2670	5340	10560
7000-7999	2940	5880	10560
8000-8999	3210	6420	10560
9000-9999	3480	6960	10560

[72] Taken directly from the St. Joseph County Ordinance, Bill No. 70-06, Ordinance No. 22-07.

* Setbacks for facilities beyond 9999 au are calculated up to the caps: 5280 for residential and 10560 for RZD and municipalities.

Sensitive Receptor Separation Distances

Sensitive Receptor	Minimum Separation Distance
Public road right of way	100 feet from road right of way
Property line of the CAFO	100 feet from the property line
Churches	One-half of the residential setback
Daycares	Equal to the RZD setback
Medical facilities	Equal to the RZD setback
Schools	Equal to the RZD setback

Water Feature Separation Distances

Water Feature	Waste Lagoon Separation Distance	Solid Waste Storage Structure Separation Distance
Public water supply well	1500 feet	300 feet
Water well on the CAFO	100 feet	100 feet
Off site well	300 feet	100 feet
Non-potable well	500 feet	100 feet
Waters of the State	500 feet	100 feet
Drainage inlets	500 feet	100 feet
Sediment basins	500 feet	100 feet
Sinkholes	500 feet	100 feet
Public tiles	75 feet from all CAFO structures	
Flood plains	300 feet from all CAFO structures plus 2 feet of freeboard	

Manure Applications Regulations:

1. Manure shall not be applied to land in excess of agronomic rate and all other requirements of 327 IAC 16-10 and this Ordinance;
2. All manure application requirements of this Ordinance shall apply to any manure derived from a CAFO within or outside of St. Joseph County and applied to land within St. Joseph County;
3. Manure may not be applied to land in a manner that allows manure or its decomposition or degradation products to become a public health nuisance off the property of the CAFO;
4. Manure may not be applied to land in a manner that allows manure or its decompositions or degradation products to contaminate the surface water or groundwater;
5. All setbacks for the application of manure required by 327 IAC 16 shall also be required by this Ordinance;
6. The Health department may order that setbacks for the application of manure be increased or any other reasonable and necessary measure to protect public health if manure is applied in a manner that releases manure to an adjacent property or becomes a public health nuisance;
7. If a person has received a variance pursuant to Sections 9.c.ii or 9.d.iii, any manure that is applied to land within the residential setback which is also within one thousand (1000) feet of a residence shall be incorporated into the soil within twenty four (24) hours of application. The Health Department may grant a variance from this requirement for very low strength liquid manure;

8. The Health Department may order that setbacks be increased or that spraying of manure be discontinued upon a determination that the spraying of manure has become a public health nuisance;
9. There shall be no application of manure to muck or marl soils where the seasonal water table is at or near the surface;
10. There shall be no application of manure to frozen ground except during emergency situations and only when approved in advance on a case by case basis by the Health Department. The Health Department may place any additional requirements deemed reasonable and necessary to protect public health and the environment on the application of manure to frozen ground;
11. Manure shall not be applied to saturated ground or in a flood prone area;
12. Liquid manure shall not be applied at a rate that exceeds the infiltration rate of the soils or that causes the ponding of liquids on the surface;
13. All solid manure shall be incorporated into the soil within twenty-four (24) hours of application unless it is applied to a crop during the normal growing season;
14. Manure shall not be surface applied when the National Weather Service predicts greater than a thirty (30) percent chance of precipitation during and four the twenty four (24) hours following the completion of manure application as reported by the National Weather Service on the morning or the day application is to be conducted.

CONCLUSION

While there are numerous practices which can prevent public health risks and contamination of water resources (e.g. methane digesters) the simplest and least expensive method of prevention is increased setbacks distance. In order to protect water quality and public health, regulatory agencies must incorporate more stringent setbacks that take into account best management practices designed to reduce the risk of environmental contamination.

The St. Joseph County Ordinance cited previously is well designed; the gradated setbacks from homes and waterways will protect the general public from noxious and potentially harmful air emissions and will protect the waters of the state and drinking water resources from contamination while promoting best management practices such as vegetated buffer strips. The best management practices listed for the land application of manure will prevent agricultural stormwater run-off and preserve the integrity of soil and nutrients. By adopting this public health ordinance as the state standard for proper manure management, the Office of the Indiana State Chemist and the Indiana Department of Environmental Management can achieve their mutual goals of safer water and healthier rural communities.