

Concentrated Animal Feeding Operations (CAFOs) and High Intensity Animal Production Systems: An Annotated Bibliography

Compiled by Jamie Florida, Hannah Bastow and Thomas K. Rohrer
Central Michigan University
Mount Pleasant MI 48859
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Section 1.—Review Articles

Background Information: Scientific and medical researchers have conducted a number of comprehensive studies that examine the public health impacts of Concentrated Animal Feeding Operations (CAFOs), high-density animal production systems and other non-traditional agricultural operations known as “animal factories”. Many of these studies have collectively concluded that residents living near animal factories show symptoms of respiratory, physical and emotional illness at levels significantly higher than control groups. Likewise, the impacts of these factories on overall environmental quality and damage to local property values and economies have also been researched.

The peer-reviewed journal, Environmental Health Perspectives has recently published six comprehensive review articles and posted them on the web. Citations and internet locations follow.

1. Thorne PS. 2006. Environmental Health Impacts of Concentrated Animal Feeding Operations: Anticipating Hazards – Searching for Solutions Environ Health Perspect: doi:10.1289/ehp.8831. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8831/abstract.html>
2. Heederik D, Sigsgaard T, Thorne PS, Kline JN, Avery R, Bønløkke J, Chrischilles EA, Dosman JA, Duchaine C, Kirkhorn SR, Kulhankova K, Merchant JA. 2006. Health Effects of Airborne Exposures from Concentrated Animal Feeding Operations Environ Health Perspect: doi:10.1289/ehp.8835. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8835/abstract.html>
3. Donham KJ, Wing S, Osterberg D, Flora JL, Hodne C, Thu KM, Thorne PS. 2006. Community Health and Socioeconomic Issues Surrounding CAFOs Environ Health Perspect: doi:10.1289/ehp.8836. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8836/abstract.html>
4. Gilchrist MJ, Greko C, Wallinga DB, Beran GW, Riley DG, Thorne PS. 2006. “The Potential Role of CAFOs in Infectious Disease Epidemics and Antibiotic Resistance” Environmental Health Perspectives: doi:10.1289/ehp.8837. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8837/abstract.html>
5. Bunton B, O’Shaughnessy P, Fitzsimmons S, Gering J, Hoff S, Lyngbye M, Thorne PS, Wasson J, Werner M. 2006. Monitoring and Modeling of Emissions from CAFOs: Overview of Methods Environmental Health Perspectives: doi:10.1289/ehp.8838. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8838/abstract.html>

6. Burkholder J, Libra B, Weyer P, Heathcote S, Kolpin D, Thorne PS, Wichman M. 2006. "Impacts of Waste from Concentrated Animal Feeding Operations (CAFOs) on Water Quality" Environmental Health Perspectives: doi:10.1289/ehp.8839. [Online 14 November 2006] <http://ehp.niehs.nih.gov/docs/2006/8839/abstract.html>

Other findings documenting adverse health effects and nuisance conditions are summarized and may be reviewed in their entirety in the journal articles cited below:

- A survey of residents living in the vicinity of a 2,500-sow facility found much higher reports of respiratory problems than those recorded in neighborhoods of farms where no livestock was raised. Another study from North Carolina found behavioral changes in individuals living near large-scale confinement operations. -Kelley J. Donham. 1998. The University of Iowa, "Occupational Health Risks for Swine Producers: Inferences for Public Health Risks of People Living in the Vicinity of Swine Production Units," in Extended Abstracts of Papers and Posters Presented, Manure Management In Harmony With the Environment and Society, hosted by The Soil and Water Conservation Society, West North Central Region, Ames, Iowa (February 10-12, 1998), pp. 299-303.
- One recent study from North Carolina found that more than half of the respondents living within two miles of a 6,000-head hog factory farm with an open lagoon reported not being able to open their windows or go outside in nice weather because of the stench. -Steve Wing and Susanne Wolf, "Intensive Livestock Operations, Health, and Quality of Life Among Eastern North Carolina Residents," Environmental Health Perspectives, Vol. 108, No. 3, (March 2000), p. 237.
- In a study of several communities in eastern North Carolina, people living close to a 6,000-head hog operation reported headaches, runny noses, sore throats, excessive coughing, diarrhea, and burning eyes significantly more often than the other groups in the study. -Steve Wing and Susanne Wolf, "Intensive Livestock Operations, Health, and Quality of Life Among Eastern North Carolina Residents," Environmental Health Perspectives, Vol. 108, No. 3, (March 2000), p. 237.
- An Iowa study evaluated the health of 18 neighbors living within a 2 mile radius of a 4,000-head hog confinement facility. Their physical and mental health was compared to a random sample of analogous rural residents who did not live near livestock facilities. Neighbors reported respiratory problems similar to those of workers on factory farms. Some of the most common symptoms reported were bronchitis and hyperactive airways, including coughing, shortness of breath, wheezing, and chest tightness. Other common symptoms among this group of residents were nausea, weakness, dizziness, and fainting. -Kendall Thu, et. al, "A Control Study of the Physical and Mental Health of Residents Living Near a Large-Scale Swine Operation," Journal of Agricultural Safety and Health, 3(1):13-26 (1997), p. 1-11.
- A study by Dr. Susan Schiffman from the Duke University Department of Psychiatry found significantly higher levels of tension, depression, anger, and fatigue among North Carolina residents who lived near large swine factory farms when compared to rural residents located

away from these facilities. According to the study, investigating mood in persons exposed to odors is an important health issue because a negative mood can affect immunity and can influence susceptibility to disease.

-Susan Schiffman, et al., "The Effect of Environmental Odors Emanating From Commercial Swine Operations on the Mood of Nearby Residents," *Brain Research Bulletin*, Vol. 37. No. 4, 369-375 (1995).

- Students from two elementary schools in rural Iowa were evaluated regarding the prevalence of asthma and airway symptoms; one was in close proximity to a 3,800 head hog CAFO, the other was distant from any CAFOs. Overall results showed that there was significant difference in the frequency of physician-diagnosed asthma among students in the two schools. The school in close proximity to the CAFO had a reported asthma occurrence of 19.7% among student; the control school showed an asthma prevalence of 7.3%.
-Sigurdarson, Sigurdur T.; Kline, Joel N. "School Proximity to Concentrated Animal Feeding Operations and Prevalence of Asthma in Students" *Chest Journal* 129/6/June 2006.
www.chestjournal.com
- At least 25% of confinement workers suffer from respiratory distress syndrome. More than 30% of swine workers suffer from additional acute respiratory condition, and organic dust toxic syndrome, related to high concentrations of bioaerosols in livestock buildings. Unhealthful concentrations of hydrogen sulfide, ammonia, inhalable particulate matter, and endotoxin were also observed in the buildings. Excessive respiratory symptoms in neighbors of CAFOs are observed relative to neighbors of low-density livestock-producing areas. Children in North Carolina attending middle schools within three miles of one or more swine CAFOs, where staff reported CAFO odors inside the school buildings, were found to have a high prevalence of wheezing compared with other middle school children.
-Donham, Kelley J.; Wing, Steven; Osterberg, David; Flora, Jan L.; Hodne, Carol; Thu, Kendall M.; Thorne, Peter S. "Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operation" *Environmental Health Perspectives* vol. 115, no. 2, Feb. 2007
- Airborne emissions of hog and cattle CAFOs can have adverse health effects on neighbors and workers. Dust collected within swine barns consists mainly of feed components, fecal matter, dander, bacteria, and mold; more than 330 volatile organic compounds (including fatty acids, alcohols, and aromatic ring compounds containing carbon, sulfur and/or nitrogen) and fixed gases were identified using gas chromatography and mass spectroscopy. Respiratory symptoms in workers were found to be associated with total and respirable dust concentrations, endotoxin in the dust, and ammonia measured in the air of barns. Feedlot dust, especially feedlots located on the prevailing, windward side of traffic, raise concern for visibility issues. A recent chain-reaction motor vehicle accident in Nebraska with multiple fatalities was attributed to feedlot dust blowing across a road. Recently studies using imaging of the brain indicates that odors have the ability to influence emotion. A variety of health effects have been reported among workers of hog confinements such as respiratory problems, mucus membrane irritation, and allergies.
-Von Essen, Susanna G.; Auvermann, Brent W. "Health Effects from Breathing Air Near CAFOs for Feeder Cattle or Hogs" *Journal of Agromedicine* vol. 10, 2005
- Malodorous aerial emissions from CAFOs consist of a mixture of volatile organic compounds (VOCs), hydrogen sulfide, ammonia, and particulates. Health complaints among CAFO workers include asthma-like syndrome, exacerbation of preexisting asthma, sinusitis, chronic bronchitis,

nasal mucous membrane inflammation, nasal and throat irritation, headaches, and muscle aches and pains. Objective measurements of lung function found acute and chronic respiratory impairment in workers as well. Acute exposures to elevated levels of hydrogen sulfide from agitated manure can cause reactive airway distress syndrome (RADS), permanent neurological damage, even death. Residents of a North Carolina community with a 6,000-head hog operation reported increased symptoms of headache, runny nose, sore throat, excessive coughing, diarrhea, burning eyes, and reduced quality of life. Neighbors of swine facilities also reported significantly more tension, depression, anger, fatigue, and confusion at the time when odors were present compared with the control group of unexposed persons. A study conducted by Duke University identified at least three mechanisms that exist by which ambient odors may produce health symptoms in communities with odorous manures and biosolids. Mechanism one: Irritation rather than the odor causes health symptoms. Mechanism two: Health symptoms occur at odorant concentrations that are not irritating; and mechanism three: A copollutant in an odorous mixture is responsible for the reported health symptom. There are technologies underway for mitigating aerial emissions such as covered in-ground anaerobic digester and nitrification biofilters; up flow biological aerated filter system; and solids separation and reciprocating wetland.

-Schiffman, Susan S.; Williams, C.M. "Science of Odor as a Potential Health Issue". Journal of Environmental Quality, vol. 34, 2005.

- Nasal irritation, coughing, wheezing, burning eyes, chronic bronchitis, dyspnea, and dizziness were observed among workers of hog CAFOs, especially those working with liquid manure. Swine confinement housing commonly has dangerous levels of agents found in air and dust including ammonia, carbon monoxide, hydrogen sulfide, particulates (inhalable and respirable dust), and endotoxins. Anaerobic processes can release odorous volatile fatty acids into the air that are absorbed onto dust particles < 10 microns in size. Such chemicals include organic acids (acetic, butyric, caprioc, valeric, luric acid, etc.), phenolics (cresols, phenol, ethylphenols), nitrogen containing compounds (ammonia, dimethyl amine, tetramethyl-pyrazine, indole, etc.), and sulfur containing compounds (dimethyl sulfide, hydrogen sulfide). Certified sealed dust masks have been found to allow 3-25% penetration of swine dusts possibly due to the considerable size distribution of aerosols < 1.0 µm in diameter. CAFO wastes contain numerous microbial pathogens: bacteria, viruses, and protozoa which are capable of causing illness in humans; multiple antibiotic resistances have been observed.

-Cole, Dana; Todd, Lori; Wing, Steve. "Concentrated Swine Feeding Operations and Public Health: A Review of Occupational and Community Health Effects" Environmental Health Perspectives vol. 108, no. 8 August 2000

Section 2—Water Contamination by Nitrates

Background Information: Groundwater is frequently contaminated by factory farm pollution, generally in the form of nitrates. Nitrate pollution, which can cause serious human health problems, seeps out of manure lagoons and into community sources of drinking water. Microorganisms from animal manure and urine and decomposing animal bodies can readily contaminate surface waters and groundwaters that receive drainage from animal factories, lagoon systems, and land areas where liquid animal waste is applied. A few journal articles are summarized and cited below:

- Increased levels of nitrates in groundwater may be the result of lagoon seepage, lagoon spills or leaks, or the over- or misapplication of manure onto the land. Manure contains nitrogen,

which changes into nitrates in the soil. After that step, the nitrates may move through the soil and accumulate in water supplies.

-Melva Okun, "Human Health Issues Associated with the Hog Industry," School of Public Health, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina (January 1998), p. 8.

- Nitrates above 10 milligrams per liter in drinking water can cause human health risks, especially to children younger than five years old, the elderly, and people with suppressed immune systems. For example, infants who drink nitrate-contaminated water may be at risk of methemoglobinemia, or "blue baby" syndrome, which can cause developmental deficiencies or even death. -"Abortions Possibly Related to Ingestion of Nitrate-Contaminated Well Water-LaGrange County, Indiana 1991-1994," *Morbidity and Mortality Weekly*, Report 26, Centers for Disease Control (July 5, 1996), pp. 569-571.

*Drinking nitrate contaminated water can cause "blue baby" syndrome in infants, leading to developmental deficiencies or death.

- In 1996, the Centers for Disease Control linked the high nitrate levels in Indiana well water near feedlots to spontaneous abortions in humans. -"Abortions Possibly Related to Ingestion of Nitrate-Contaminated Well Water-LaGrange County, Indiana 1991-1994," *Morbidity and Mortality Weekly*, Report 26, Centers for Disease Control (July 5, 1996), pp. 569-571.
- A survey of domestic drinking-water wells in nine Midwestern states by the Centers for Disease Control found that 13% of the 5,500 samples taken were above the drinking water maximum contaminant standard of 10 mg/l. -"A Survey of the Quality of Water Drawn from Domestic Wells in Nine Midwest States," National Center for Environmental Health (September, 1998).
- A Center for Disease Control Study compared the contamination rates of samples from wells that, in the past five years, had manure applied within 100 feet of the wellhead to the rates of samples where no applications had occurred. This analysis found that the use of manure doubled the likelihood of an elevated nitrate level. -"A Survey of the Quality of Water Drawn from Domestic Wells in Nine Midwest States," National Center for Environmental Health (September, 1998).
- As of 1998, close to 1,600 wells located near factory farms in North Carolina were tested for nitrate contamination. 34% of the wells showed nitrate contamination; 10% of the wells had a nitrate level that exceeded the drinking water standard. The state's Department of Health and Human Services stated that the cause of contamination was leaking hog lagoons and hog wastewater sprayfields.

-Kenneth Rudo, Ph.D., "Groundwater Contamination of Private Drinking Well Water by Nitrates Adjacent to Intensive Livestock Operations," Occupational and Environmental Epidemiology Branch, Department of Health and Human Services, *Proceedings of Workshop on Atmospheric Nitrogen Compounds II*, The Friday Center, Chapel Hill, NC (June 7-9, 1999), p. 413.

- A study in North Carolina found severe seepage losses of nitrogen from more than 50% of the lagoons tested by the state, posing a risk to groundwater.

-R.L. Huffman and P.W. Westerman, "Estimated Seepage Losses from Established Swine Waste Lagoons in the Lower Coastal Plain in North Carolina," *Transactions of the ASAE* 38(2):449-453 (1995).

- In a North Carolina state study, the nitrates in shallow groundwater below fields sprayed with liquid manure have been measured at rates five times the human health standard; in long-term sprayfields, the rates have been as high as thirteen times the human health standard.

-Remarks of Joe Rudek, Ph.D., Senior Scientist, North Carolina Environmental Defense Fund in *Hog Waste and Environmental Quality in North Carolina, A Report on the Save Our State Forum*, Raleigh, North Carolina (June 11, 1998), p. 47.

- On June 7, 2001, EPA Region 6 exercised a rarely used emergency power under the federal Safe Drinking Water Act to compel five hog operations in Kingfisher and Major Counties in Oklahoma to provide area residents with safe drinking water. In March and May 2001, EPA sampled drinking-water supply wells and found nitrate concentrations as high as 15.7 mg/l, where the acceptable level is 10 mg/l. Nitrates from the hog operations also contaminated the aquifer, which serves as an underground source of drinking water for four nearby households.

-In the Matter of Seaboard Farms, Inc., Shawnee Funding Limited Partnership, PIC International Group, Inc., United States Environmental Protection Agency Region 6, Emergency Administrative Order, Docket Number: SDWA-06-02001-1239.

- Thirty-eight segregated water monitoring sample stations were set up in eastern Iowa to determine if CAFOs had an impact on river nutrient content. The study found that the Eastern Iowa Study Area was a major contributor of nitrate to the Gulf of Mexico, exporting approximately 91,000 metric tons per year. This amount represents as much as 9.6% of the annual nitrate flux entering the Gulf from the Mississippi River, yet the Eastern Iowa Study Area represents only 1.5% of the land area of the Mississippi and Atchafalaya River Basin. The major watershed inputs of nitrogen include applied fertilizer, nitrogen fixation by soybeans, and high density CAFOs. The U.S. EPA set nitrate levels no higher than 10 mg/L for drinking water, however, instances of high animal densities were associated with nitrate concentrations above 15 mg/L. Correlation and regression analyses point toward animal unit density, and therefore, CAFO density being the a prime indicator of nitrate concentrations in streams.

-Weldon, Mark B.; Hornbuckle, Keri C. "Concentrated Animal Feeding Operations, Row Crops, and Their Relationship to Nitrate In Eastern Iowa Rivers" *Environmental Science and Technology* vol. 40, no. 10, 2006.

- Chloride was used in the study as a conservative tracer along with NO₃ to identify contaminated wells below the waste spray area of a CAFO. Present water quality standards allow no more than 10 mg/L nitrate-N (NO₃-N) in drinking water. The mean concentrations of NO₃-N increased from <5 mg/L above the waste area, to > 24mg/L immediately below it. Chloride mean concentrations also increased in wells from <25 mg/L above it, to >31 mg/L below it. There was a significant linear relationship between Cl and NO₃ concentrations in samples from all wells. Waste from the CAFO was the obvious source as high NO₃ concentrations and δ₁₅NO₃ values > +10 in samples immediately south of the spray area (believed direction of groundwater movement)

-Toetz, Dale. "Nitrate in Ground and Surface Wasters in the Vicinity of a Concentrated Animal Feeding Operation". *Archiv für Hydrobiologie*, vol. 166, issue 1, 2006
- A study conducted in North Carolina showed the positions of CAFOs in relation to water bodies using satellite images. The intent was to investigate the potential that a flood event could lead to environmental dispersion of animal wastes containing a number of biologic and chemical hazards; this was compared to the geographic coordinates of 2,287 CAFOs permitted by the DWQ. Satellite images taken approximately one week after Hurricane Floyd hit North Carolina were used. The study also looked at the occurrence of African Americans living in areas with CAFOs likely to be flooded. Results demonstrated that in a geographic area of 171,498 residents, 2,286 active CAFOs were registered in areas of inundation; more than one-third of the residents were African American where 58.1% used well water. Satellite-based images estimates indicate that 60,546 people inhabited block groups with two or more flooded operations, and 110,952 people inhabited block groups with one flooded operation; this estimate does not account for those living downstream from the flooded CAFOs. Areas with flooded CAFOs happened where nearly 60% of households used well water.

-Wing, Steven; Freedman, Stephanie; Band, Lawrence. "The Potential Impact of Flooding on Confined Animal Feeding Operations in Eastern North Carolina" *Environmental Health Perspectives* vol. 110, no. 4 2002
- Study conducted at the University of Arizona tested application rates of manure from CAFOs and nitrogen up-take by alfalfa. The study found that manure and compost applications demonstrated inhibition of biologic nitrogen-fixation by nitrogen application through organic compounds. The accumulation of phosphorus in the soil may be of concern in areas where surface water is near.

-Martin, E.C.; Slack, D.C.; Tanksley, K.A., and Basso, B. "Effects of Fresh and Composted Dairy Manure Applications on Alfalfa Yield and the Environment in Arizona". *Agronomy Journal* 98, no. 1 Jan. /Feb. 2006
- Current production, storage, and disposal methods present a challenge to manage wastes and minimize ammonia (NH₃) losses to the environment. Haper et.al. found that lagoon based storage systems are inefficient, with 48% nitrogen lost as NH₃ and N₂ with no further reuse of it in the agroecosystem. There is critical need for improvement in nitrogen conservation from lagoon-based waste management.

-Harper, Lowry A.; Sharpe, Ron R.; Parkin, Tim B.; De Visscher, Alex; van Cleemput, Oswald; Byers, F. Michael. "Nitrogen Cycling Though Swine Production Systems: Ammonia, Dinitrogen, and Nitrous Oxide Emissions" *Journal of Environmental Quality* vol. 33, July-August 2004

Section 3—Water Contamination by Pathogenic Microbes

Background Information: Chemical pollutants and pathogens from animal waste pose a public health risk when leaked into surface water supplies like community rivers and streams. Fecal bacteria and pathogens from factory farms are probably responsible for several illness outbreaks in the United States.

- From 1995 to 1998, there were at least 1,000 spills or other pollution incidents at livestock feedlots in ten states, and 200 manure-related fish kills that resulted in the death of 13 million fish.
-Merritt Frey, et al., *Spills and Kills: Manure Pollution and America's Livestock Feedlots*, Clean Water Network, Izaak Walton League of America and Natural Resources Defense Council (August 2000), p. 1.
- While seepage can be reduced with the use of clay liners, even clay-lined lagoons may leak from several hundred to several thousand gallons per acre per day.
-Correspondence from Dennis Ramsey, North Carolina Department of Health and Natural Resources, to Karen Priest (May 19, 1997).
- A North Carolina study looking at the human health risks of factory farms found that several of the pathogenic microbes in swine and poultry wastes can infect people. The researchers also found that the “bacterial indicator levels in swine lagoon effluents are much higher than allowed for municipal wastewater effluents discharged to land or water.” Thus, the land application of swine-lagoon effluent could pose a risk to communities that rely on groundwater for drinking water and could also degrade the quality of nearby surface waters.
-V.R. Hill and M.D. Sobsey, “Microbial Indicator Reductions in Alternative Treatment Systems for Swine Wastewater,” Water Science and Technology 38 (12):119-122 (1998).
- A study completed by the Center for Disease Control of nine large animal confinement sites in Iowa found chemical pollutants, pathogens, metals, bacteria, nitrates, and parasites in lagoons and other areas in and around the sites. Samples from the earthen lagoons contained the highest levels of chemical pollutants and pathogens. Their findings suggest that both chemical pollutants and microbial pathogens may move through soil from the site of the lagoon and flow over the land away from where the manure was applied.
-Carol S. Rubin, DVM, MPH, Chief, Health Studies Branch, “Report to the State of Iowa Department of Public Health on the Investigation of the Chemical and Microbial Constituents of Ground and Surface Water Proximal to Large-Scale Swine Operations,” National Center for Environmental Health, Centers for Disease Control and Prevention (October-December 1998).
- In May 2000, in Walkerton, Ontario, 1,300 cases of gastrointestinal problems occurred and 6 people died from an outbreak of *E.coli*. The Ontario Ministry of Health and Long-Term Care determined that the likely source was cattle manure runoff from a farm adjacent to a drinking water supply well.
-“Waterborne Outbreak Associated with a Contaminated Municipal Water Supply,”

Walkerton, Ontario, May-June 2000, *Canada Communicable Disease Report*, Vol. 26-20, (October 15, 2000).

- A study of the effects of lagoon spills on the surface waters of North Carolina found that there are high counts of fecal coliform -indicating the presence of bacteria- even 61 days after a spill. Natural or man-made disturbance of contaminated water resuspend potentially dangerous amounts of bacteria and other microbes back into the water column for weeks after a spill.
-Michael A. Mallin, "Impacts of Industrial Animal Production on Rivers and Estuaries," *American Scientist*, (January-February, 2000), pp. 26-37.
- In 1993, *cryptosporidium*, a pathogen found in Milwaukee's drinking water, made 400,000 people sick and led to the deaths of more than 100 people. A suspected cause was dairy manure.
-David Letson and Noel Gollehon, "Confined Animal Production and the Manure Problem," *Choices* (Third Quarter 1996), p.18.
- Waste can enter surface and groundwater supplies even in dry weather through spills or leaks from lagoons and from over-spraying manure onto croplands. While water contamination via precipitation events and snow pack melt has been well documented, waste from factory farms can get into surface waters and groundwater even in dry weather.
-U.S. Environmental Protection Agency, Office of Water, Environmental Assessment of Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Farming Operations, EPA-821-B- 01-001 (January 2001), p. 2-7.
- In 1995, an eight-acre animal waste lagoon in North Carolina burst, spilling 25 million gallons of animal waste into the New River. The spill killed 10 million fish and closed 364,000 acres of coastal wetlands to shellfishing.
-Ted Williams, "Assembly Line Swine," *Audubon Magazine* (March-April 1998), p. 28.
- Major pathogens in food products which are believed to develop at the farm sites include *Salmonella*, *Campylobacter*, *E. coli O157:H7* and related *EHEC*, *Shigella*, *Listeria*, *Yersinia*, *Aeromonas*, *Arcobacter*, *Vibrio*, and *Clostridium*; the parasites *Cryptosporidium* and *Toxoplasma*; and various viruses, hepatitis A Norwalk. A study by ARS scientists surveyed *E. coli O157:H7* infection in feedlot cattle presented for slaughter and found 28% of all animals tested were found to be infected. Additionally, infection was also widespread, with 72 percent of slaughter groups testing positive for *E. coli O157:H7*.
-U.S. Department of Agriculture, Agricultural Research Service. National Programs, Food Safety (animal and plant products). National Program Annual Report, FY 2000
http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=108

Section 4—Water Contamination by Hormone Disrupters and Chemical Transformations

Background Information: An estimated 90% of beef cattle are feed growth promoting hormone supplements in the United States. The use of such feed additives contribute to substantial amounts of various estrogens and androgens released into local streams and groundwater receiving runoff from CAFO lagoons. This has been found to support feminization and masculinization in aquatic species. Metal compounds are also applied to the land surrounding CAFOs in the form of waste. Microorganisms convert metals such as organoarsenic added to poultry feed into harmful chemicals such as inorganic arsenite and inorganic arsenate, both human carcinogens. Inorganic arsenic in waste and soil is readily leachable and may therefore move into groundwater.

- Commercial immunoassay kits were used by ARS scientists to analyze samples related to manure handling practices for levels of endogenous hormones 17-estradiol and testosterone in animal manure. Results demonstrated that hormones were present in water adjacent to manure pits and that degradation of the hormones occurs when it is allowed to stand at 20°C. They also found that the hormones were water soluble and residues could be transported in the environment.
-“Significance of the endogenous hormones 17-estradiol and testosterone in animal manure” U.S. Department of Agriculture, Agricultural Research Service. National Programs, Food Safety (animal and plant products). National Program Annual Report, FY 2000
http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=108
- A Nebraskan study looked at whether endocrine activity could be detected in natural stream/river systems below feedlots. They did this by analyzing the reproductive endocrinology and secondary sex characteristics of wild fish populations of adult flathead minnows, *Pimephales promelas*. Significant concentrations of estrogens and androgens have been reported in ponds and streams receiving runoff from fields fertilized with chicken litter; concentrations, depending on application rate, have been observed as high as 1,280 ng/L. In the US, growth promoting hormone supplements are used in the production of approximately 90% of the beef cattle. The data collected clearly showed androgenic activity from water obtained below feedlots; however the casual agents were not identified. Trenbolone acetate, a synthetic androgenic anabolic steroid used in cattle production, is metabolized into trenbolone- β , the biologically active molecule; it has a half-life of >260 days in liquid manure. Trenbolone- β was found to act as a potent androgen agonist in CV-1 cell assays used to test the flat head minnows during the study; trenbolone acetate is known to be 8-10 fold times more potent than native T in cattle. Flat head minnows exposed to were said to trenbolone- β displayed severely altered female and male reproductive biology. Each site evaluated held cattle which had growth implants.
-Orlando, Edward F.; Kolok, Alan S.; Binzcik, Gerry A.; Gates, Jennifer L.; Horton, Megan K.; Lambright, Christy S.; Gray, L.Earl; Soto, Ana M.; Guillette, Louis J. “Endocrine-Disrupting Effects of cattle Feedlot Effluent on an Aquatic Sentinel Species, the Fathead Minnow” Environmental Health Perspectives vol. 112, no. 3, 2004
- Manure from CAFOs account for 90% of the estrogen load in the environment; estrogens are the most potent endocrine disrupter, even at nanogram per liter levels. A number of aquatic species such as turtles, trout, and minnows may be sexually inhibited or even reversed by the presence of natural estrogens; this is seen at concentrations in the range of a few tens of ng/L. Natural steroidal estrogens are contributed predominately by humans and livestock through feces and urine. A review by Lange et al. reported a total estrogenic activity of 48.5 metric ton 17 β -estradiol equivalent (EEQ) per year contributed by livestock excretion in the United States. A 1999-2000 study conducted by the US Geological Survey assessed 139 streams from 30 states and revealed that the bodies of water contained endocrine-disrupting chemicals, including estrogen compounds, with 17- β estradiol and Estriol concentrations as high as 200 and 112 ng/L. The frequent administration of estrogenic

hormones as growth promoters may increase the livestock's output of estrogens. Estrogens derived from animals are excreted in urine as conjugate of sulfate or glucuronide which are biologically inactive; however, they act as a precursor hormone reservoir that can be converted to the free active form by microbes such as *E. coli*.

-Khanal, Samir Kumar; Xie, Bin; Thompson, Maichael, L.; Sung, Shihwu; Ong, Say-kee; Van Leeuwen, J. (Hans). "Fate, Transport, and Biodegradation in the Environment and Engineered Systems". Environmental Science and Technology, vol. 40, no. 21, 2006

- Among more than 70,000 synthetic chemicals registered for commercial use, few were tested for hormonal activity. Anabolic agents used in the cattle industry to increase growth. In the United States the primary growth promoters are the androgens testosterone, trenbolone acetate, the estrogen 17 β -estradiol and zeranol, as well as the progesterones progesterone and melengesterol acetate. Estrogenic esters, which are more potent than the parent compound, have been found in the fatty acids on steroid-treated cattle even though treatment is stopped days before slaughter. The ultimate fate of many excreted anabolic agents is unknown. Recent studies have found that metabolites of trenbolone acetate can remain in manure piles for more than 270 days; this demonstrates the likelihood of the agents being found downstream from CAFOs. After testing the water downstream from CAFO feedlots, the researchers concluded that significant amounts of estrogenic and androgenic activity were released. The masculinization of female fish were found at site 2 (0.5 km from feedlot) and site 3 (0.5 km from feedlot).

-Soto, Ana M.; Calabro, Janine M.; Prectl, Nancy V.; Yau, Alice Y.; Orlando, Edward F. Daxenberger, Andreas; Kohk, Alan S.; Guiliette Jr, Louis J.; le Bizec, Bruno; Lange, Iris G.; Sonnenschein, Carlos. "Androgenic and Estrogenic Activity in Water Bodies Receiving Cattle Feedlot Effluent in Eastern Nebraska, USA". Environmental Health Perspectives, vol. 112, no. 3 2004

- There are a number of additives to animal feed used in CAFOs which may have adverse health impacts on both human and animal health including ingredients, biological and chemical agents, and feed production practices. Animal waste is routinely used in animal feed; the FDA does not endorse the practice and has issued statements voicing concern about the presence of pathogens and drug residues in the animal waste, particularly poultry litter. Fats originating from both plants and animal sources are used in animal feed and may contain contaminants such as dioxins and PCBs; roughly 8% of feed can be composed of fats alone. Antibiotics are administered via feed to promote growth and improve feed efficiency; this practice has shown to select for antibiotic resistance in both commensal and pathogenic bacteria in the animals, subsequent animal food products and air/soil/water samples. It is estimated that as much as 60-80% of all antibiotics produced in the U.S. are used in animal feed. Metal compounds are added to feed including roxarsone which is converted into inorganic arsenite and inorganic arsenate, both human carcinogens. Agents including bacterial pathogens (*Salmonella*, *E. coli* 0157:H7), antibiotic-resistant bacteria (*E. faecium*, *E. coli*, *C. jejuni*, *Salmonella*), prions (causative agent of BSE), metals (arsenicals: roxarsone, As^{III}, As^V), mycotoxins (aflatoxins, ochratoxins, fumonisins, Variant Creutzfeldt-Jakob disease), polychlorinated dibenzofurans, polychlorinated dibenzo-p-dioxins, and PCBs.

-Sapkota, Amy R.; Lefferts, Lisa Y.; McKenzie, Shawn; Walker, Polly. "What Do We Feed to Food-Production Animals? A Review of Animal Feed Ingredients and Their Potential Impacts on Human Health" Environmental Health Perspectives vol. 115, no. 5, May 2007

- A study conducted by the American Society of Agricultural Engineers demonstrated how GIS systems could be used to understand the impacts of buffers and setbacks on land availability for CAFOs. The goal was to determine the number of parcels of land that could be used as a site for a

CAFO after various buffers (distance surrounding surface water that may be excluded from barns, waste lagoons, etc.) and setbacks (areas which exclude barns, lagoons, waste storage and treatment facilities, etc.) were applied. Setbacks and buffers would be used to prevent air and water contamination and protect neighbors of CAFOs. After buffers were in place, less than 50% of land (in the three Georgia counties) would be available for consideration of a CAFO site. A dramatic decrease in available land for CAFOs was shown for the counties when buffer size increased from 0 to 152.5 m. When proper buffers and setbacks are in place, only 7% of land would be available.

-Worley, J.W.; Rupert, C.; Risse, L.M. "Use of GIS to Determine the Effect of Property Line and Water Buffers on Land Availability" Applied Engineering in Agriculture, vol. 17, issue 1, 2001.

- In the United States there are approximately 8.5 billion broiler chickens are produced annually; this results in an approximate total waste production between 12 and 23 billion kilograms. Arsenic in poultry waste results from the use of arsenicals added to feed for growth promotion and prevention of parasitic prevention. The U.S. Geological Survey has calculated, based on arsenic concentrations measured in poultry wastes, between 250,000 and 350,000 kg arsenic is applied annually to the land. Strong evidence exists that the organoarsenic added to poultry feed is rapidly transformed to inorganic arsenic in wastes and soils; this form of arsenic is readily leachable and may therefore move into groundwater. A partnership has been implemented between a major poultry producer and Scotts, the nation's leading source of consumer garden products, to produce fertilizer pellets for the use in landscaping, and gardening. Also, the practice of incinerating poultry ash and litter has increased; three biomass-fueled power plants owned by Energy Power Resources are currently in operation in the United Kingdom, several are planned for the United States. The use of CAFO poultry waste in such settings will create a variety of opportunity for human exposures to arsenic. Arsenic is recognized as a human carcinogen by the U.S. EPA, National Research Council, International Agency for Research on Cancer, National Toxicology Program, and American Conference of Industrial Hygienists; exposures have also been associated with increased risk of heart disease, diabetes, neurological effects, and birth defects in humans. Current policies for poultry waste focus on nutrient content and, as a result, do not take into account the presence of pharmaceuticals, pathogens, and heavy metals in waste. Animal waste is not currently classified as hazardous waste by the U.S. EPA. Economic analyses have demonstrated that removal of growth-promoting antimicrobials, such as arsenic, has come at no net cost for the poultry industry.
-Nachman, Keeve E.; Graham, Jay P.; Price, Lance B.; Silbergeld, Ellen K. "Arsenic: A Roadblock to Potential Animal Waste Management Solutions". Environmental Health Perspectives, vol. 113, no. 9 2005

Section 5 —Emissions of Toxic Air Pollutants

Background Information: Scientific studies are beginning to prove what neighbors to factory farms know well—manure lagoons emit toxic airborne chemicals that can result in human health problems. Air pollutants like hydrogen sulfide and ammonia can cause both immediate and long-term respiratory problems.

- Studies show that lagoons emit toxic airborne chemicals that can result in human health problems through inflammatory, immunologic, irritant, neurochemical, and psychophysiological mechanisms.
-Steve Wing and Susanne Wolf, "Intensive Livestock Operations, Health, and Quality of

Life Among Eastern North Carolina Residents,” Environmental Health Perspectives, Vol. 108, No. 3 (March 2000), p. 233.

- Researchers indicate that feedlot odor may contain 170 separate chemical substances.
-Confined Livestock Air Quality Committee of the USDA Agricultural Air Quality Task Force, *Air Quality Research and Technology Transfer White Paper and Recommendations for Concentrated Animal Feeding Operations*, Washington, D.C. (July 12, 2000), p. 7.
- A report released by the Minnesota Pollution Control Agency (MPCA) indicates that lagoon emissions contain toxic components and greenhouse gases, including hydrogen sulfide, ammonia, and methane.
-“Feedlot Air Quality Summary: Data Collection, Enforcement and Program Development,” St. Paul, Minnesota (March 1999).
- Hydrogen sulfide, a gas emitted from animal waste lagoons, can cause eye, nose, and throat irritation, diarrhea, hoarseness, sore throat, cough, chest tightness, nasal congestion, heart palpitations, shortness of breath, stress, mood alterations, sudden fatigue, headaches, nausea, sudden loss of consciousness, comas, seizures, and even death.
-Yale Center for Environmental Law and Policy, Student Clinic, *Controlling Odor and Gaseous Emission Problems from Industrial Swine Facilities: A Handbook for All Interested Parties*, New Haven, Connecticut (Spring 1998), p. 10, <http://www.yale.edu/envirocenter/clinic/swine/swine2.html>.
- A study by the Minnesota Pollution Control Agency (MPCA) evaluated the emissions of hydrogen sulfide (a gas toxic to humans) from 42 animal feedlots that used lagoons and cement pits. The study found that concentrations of hydrogen sulfide, estimated by using a standard EPA approach to model emissions, exceeded the state standard significantly, even 4.9 miles away from the lagoons.
-Gregory C. Pratt, Ph.D., “Dispersion Modeling Analysis of Air Emissions from Feedlots in Nine Townships in West-Central Minnesota,” Air Quality Division, Minnesota Pollution Control Agency, St. Paul Minnesota (May 26, 1998).
- Air quality monitoring by the Minnesota Department of Health affirmed that toxic gas emanating from the manure lagoon of ValAdCo in Renville County, one of the state’s largest operations for finishing hogs for market, posed a potential threat to human health. After two years of testing the swine facility, the state found hydrogen sulfide levels far exceeding the state standard (50 parts per billion), 53 times in 1998, and 271 times in 1999 and 2000.
-Tom Meersman, “Attorney General’s Office Breaks Off Talks on Feedlot Odor,” *Minneapolis Star Tribune* (June 15, 2001); Tom Meersman, “Olivia-Area Hog Operation Continues to Violate Air Rules,” *Minneapolis Star Tribune* (June 14, 2001).
- In Sampson County, North Carolina, the amount of ammonia in the rain doubled between

1985 and 1996, a period of major expansion in the hog industry. Ammonia causes irritation of the lungs, eyes and nose.

-Stuart Leavenworth and James Eli Shiffer, "Airborne Menace," *Sunday Raleigh News and Observer* (July 5, 1998), quoting Viney Anaja, a research professor in the Department of Marine, Earth and Atmospheric Sciences at North Carolina State University, p. 1A.

*During an eleven year period of major expansion of the hog industry in one North Carolina county, it was found that the amount of ammonia (an irritant to humans) in the rain doubled.

- In late April 2000, EPA issued a Notice of Violation under the Clean Air Act against seven Premium Standard Farm factory farms in Missouri stating that the facilities “emit, in addition to odors, regulated pollutants such as particulate matter and hydrogen sulfide.”
-U.S. Environmental Protection Agency, Notice of Violation, Premium Standard Farms, Inc., Office of Compliance and Enforcement (April 26, 2000).
- The fumes from animal factories can threaten their neighbors’ health, as Julie Jansen discovered. In 1995, Jansen, who operated a day care center in Olivia, Minnesota, was advised to take the children away from the home after they were suffering from nausea, diarrhea, headaches and other symptoms of hydrogen sulfide poisoning. Hog factories, more than a mile from her home, were contaminating the air with hydrogen sulfide and other pollutants.
-Personal communication with Julie Jansen, Clean Water Action Alliance of Minnesota, Olivia, Minnesota.
- Regulations of the Missouri Air Conservation Commission as well as the Missouri Air Pollution Control Program involve those which limit the amount of acceptable odor from CAFOs; scentometers (field olfactometry) are used as a screening tool. The rules indicate that if an odor is detectable by an investigator at a dilution ratio of 5.4 parts carbon filtered air to 1 part odor-laden air, then the air sample should be collected and sent to an olfactometry laboratory; if the detection threshold of the sample is above then the CAFO would be in violation. Research was conducted to determine if the numbers used in the rule are too low for the regulatory standards. Conclusions state that appropriate regulatory limits of a laboratory olfactometry determined DT of 110 was found based on the mean of odorous air samples collected when a field olfactometer 7:1 dilution-to-threshold was observed.
-Newby, B.D.; McGinley, M.A. “Ambient Odour Testing of Concentrated Animal Feeding Operations Using Field and Laboratory Olfactometers” Water Science and Technology vol. 50, no. 4 2004
- An experimental approach to define, prioritize, track, and develop a detailed odorant ranking profile analysis from equivalent sensory graded “best” and “worst” case samples, using gas chromatography-olfactometry. Ranking profiles were based on a number of factors including odor characteristic, detectability, and perceived intensity downwind from a 5400 head swine finish facility as well as a 50,000 head capacity cattle feedyard in Texas. *P-cresol* appeared to be the single most important individual odorant relative to swine facility series of tests within 0.5 m, followed in rank by 2'-aminoacetophenone, and isovaleric acid. At a distance of 250m, the ranking was *P-cresol*, 2'-aminoacetophenone, and p-ethylphenol. Particular attention was necessary for *P-cresol* due to relative low volatility and high polarity which may result in slow diffusion; surface adsorption and

“stickiness” which may magnify the concentration build-up and odor impact through permeation, adsorption, and re-emission effects of material at or near the source; sensitivity to the flooding out effect which could magnify or induce weather related odor travel.

-Wright, Donald W.; Eaton, David K.; Nielsen, Lawrence T.; Kuhrt, Fred W.; Koziel, Jacek A.; Spinhirne, Jarrett P.; Parker, David B. “Multidimensional Gas Chromatography-Olfactometry for the Identification and Prioritization of Malodors from Confined Animal Feeding Operations” Journal of Agricultural and Food Chemistry vol. 53, no. 22, 2005

- The research presented involved an exposure chamber to systematically investigate the physiological and psychological responses in human volunteers that result from exposure to a known level of emissions of swine confinement air in a controlled environment. The use of the human chamber allowed for direct dose-response evaluation of potential acute health effects from a specified level of airborne emissions. The subjects consisted of forty-eight healthy adults (mean age of 26 ± 9.46 years) having no history of respiratory illnesses, allergies or asthma. Results indicated that a one-hour exposure to odorous swine air in an environmental chamber, with levels which could occur downwind from a swine facility, had no significant acute effects on vital signs, lung function, nasal inflation, salivary IgA, mood, attention, or memory in the volunteers. However, the rapid onset of self-reported symptoms of headaches, eye irritation, and nausea were significantly more prevalent in the volunteers during the one-hour exposure to the swine air compared to the clean air. The underlying cause of such symptoms is unknown but may be due to the combined load of all of some components of the air (H_2S , ammonia, VOC's, particulates, and endotoxin). Another possibility is that the self-reported symptoms are innate or learned warning signals of potential health effects at higher concentrations or with prolonged exposure. Several experimental studies suggest that increased sensitivity to odor can develop with repeated exposure; this effect is pronounced in women. Tolerance however has been reported to occur in some chronically exposed workers, it is not known though whether the tolerance developed in an analogous manner at lower concentrations at areas downwind from swine facilities.

-Schiffman, Susan S.; Studwell, Clare E.; Landerman, Lawrence R.; Berman, Katherine; Sundy, John S. “Symptomatic Effects of Exposure to Diluted Air Sampled from a Swine Confinement Atmosphere on Healthy Human Subjects”. Environmental Health Perspectives vol. 113, no. 5 2005

- Ammonia (NH_3), after deposition to land, can increase acidification and nutrient nitrogen enrichment of sensitive habitats. In addition, NH_3 reacts with atmospheric acids forming (secondary) particulates that contribute significantly to the burden of particulate matter, which is likely to threaten human health in Europe. Agriculture is estimated to produce 80-90% of European NH_3 emissions, similar to that of the USA. The incorporation of manures into arable land is one of the most cost-effective measures to reduce emissions from housing facilities, while applying slurry by band spreader or injection and covering slurry stones.

-Webb, J.; Menzi, H.; Pain, B.F.; Misselbrook, T.H.; Dämmgen, U.; Hendriks, H.; Döhler, H. “Managing Ammonia Emissions from Livestock Production in Europe”. Environmental Pollution 135, 2005.

- Research was conducted to evaluate NH_3 emissions from two swine confinement housings in the coastal plains of North Carolina. Seasonal differences in emissions were evident; ammonia concentrations in the houses were 2.4 times higher on a per-animal basis during the winter than summer due to decreased air exchange for heat conservation in the winter months.

-Harper, Lowry A.; Sharpe, Ron R.; and Simmons, John D. “Ammonia Emissions from Swine Houses in the Southeastern United States”. Journal of Environmental Quality 33, March/April 2004

- Physical and chemical factors were measured on primary and secondary lagoons on three production farm types in the Central Great Basin of the United States to find NH₃ emissions from swine waste processing lagoons. Current estimates by the USEPA and the state of North Carolina suggests 89-90% of the nitrogen inputs to anaerobic lagoons in CAFOs were lost to the atmosphere; 71 and 36% of the nitrogen is volatilized as NH₃ gas.
-Harper, Lowry A.; Weaver, Kim H.; and Dotson, Richard A. “Ammonia Emissions from Swine Waste Lagoons in the Utah Great Basin”. Journal of Environmental Quality 35, no. 1 Jan. /Feb. 2006
- A USDA sponsored study, conducted by scientists from the University of Iowa, Los Alamos National Laboratory, and the National Soil Tilth Laboratory, used a miniature elastic lidar, a Raman lidar, and 3D sonic anemometers, along with other chemical detectors to demonstrate the movement of aerosols from hog confinements. Emission rates were calculated by concentration and dispersion of the plume, and showed that it reached approximately 30 m in height. They found that the plume of chemicals coming from the hog confinements rises vertically before it travels horizontally in the direction of the wind. The vertical rise can be attributed to turbulence in the atmosphere due to the pressure change around the barns themselves and the buoyancy of hotter air within the barns. This disproves the idea of line-source travel and shows that shelterbelts (such as trees and shrubs that are planted close to the confinement barns to induce mixing and dispersion) have little practical value. The reason for such a dramatic rise in the plume is currently unknown.
-William Eichinger, Daniel Cooper, John Prueger, Tim Hart, Forest Goodman, Dick Pfeiffer, Jennifer Nichols, Robert Knight, Gregory Weber, “Measurements of Aerosols Emitted From Hog Confinements,” 2003 <http://www.iuhr.uiowa.edu/projects/pigbarn/>.

Section 6—Microorganisms & Antibiotic Resistant Bacteria

Background Information: The presence of antibiotic resistant bacteria has repeatedly been found in the air, water and soil surrounding CAFOs. The excess use of antimicrobials in the industry enables numerous synthetic antimicrobials and antibiotic resistant bacteria to exist in the environment and threaten the health of humans and animals.

- Air samples were taken 25 m upwind of a CAFO facility, inside the facility, and 25, 50, 150 m downwind of a CAFO to test for the presence of bacterial organisms. The average bacterial concentration for each location demonstrated that the CAFO was undoubtedly the source of the elevated bacterial levels, and a pattern was easily discernable. The lowest level of culturable bacterial organisms was found at 25 m upwind at an average 82 CFU/m³; the maximum level was found inside the facility at 18,185 CFU/m³ (22,200% higher than that recovered upwind). There was a one-log decrease from the facility concentration 25 m downwind of the facility and a two-log decrease from the facility concentration 100 m downwind. Therefore, 100 m from the facility allows a loss of 99% of the bacterial concentration from what was recovered inside the CAFO, but it was still 250% higher than the density of organisms found upwind of the facility. The farthest sampling site was 150 m downwind, yet was found to have and averaged 2.5 times the number of bacteria as the sampling location 25 m upwind of the facility. The estimated optimal distance placement

distance of a CAFO facility would be some 200 m from a residential area when considering culturable bacteria strains (not pathogens or antibiotic resistant strains).

-Green, Christopher F.; Gibbs, Shawn G.; Tarwater, Patrick M.; Mota, Linda C.; Scarpino, Pasquale V. "Bacterial Plume Emanating from the Air Surrounding Swine Confinement Operations" Journal of Occupational and Environmental Hygiene, January 2006

- The considerable use of sub-therapeutic doses of broad-spectrum antibiotics to swine feed have promoted swine growth, improved the efficiency of feed conversion, and affected the bacterial and fungal disease prophylaxis among the animals. A study of two CAFO sites (A & B) with 1,000+ cattle showed increased microbial resistance within the facilities and downwind; microorganisms upwind showed more susceptibility to antibiotics. Multiple resistances were demonstrated to antibiotics they were exposed to, antibiotics in the same family, and those used in human medicine. Site A clearly showed resistance patterns signifying animals were the source of the resistance; no resistance bacteria were found upwind. Total CFU (colony forming units) of both respirable bacteria and fungi at a level of $10^3/\text{m}^3$ of air was used as the indicator of potential human health hazards. The study consistently found levels of total microorganisms above 10^3 CFU/ m^3 of air inside and downwind of the CAFOs in the presence of animals. The authors of the study believe that the antibiotic resistance observed is most likely feed-related, although it could not be concluded positively.

-Gibbs, Shawn G.; Green, Christopher F.; Tarwater, Patrick M.; Scarpino, Pasquale V. "Airborne Antibiotic Resistant and Nonresistant Bacteria and Fungi Recovered from Two Swine Herd Confined Animal Feeding Operations" Journal of Occupational and Environmental Hygiene, November 2004

- A Sunnyside Area, Idaho study was conducted to test the ground water in wells surrounding a large CAFO. Well water collected near the CAFO contained 0.310 $\mu\text{g}/\text{l}$ sulfamethazine and 0.170 $\mu\text{g}/\text{l}$ sulfamethoxine. Sulfonamides are a synthetic antimicrobial, so their detection in groundwater is not expected from natural sources. The sulfonamide drugs are not approved for human usage, and therefore their detection is an indicator of contamination from animal sources. Manure application increase soil pH typically between 6 and 7.5, within this pH range, most sulfonamides are ionized and consequently increased soil mobility can be expected. Resistant genes from wastewater lagoons of CAFOs have been found to leach into groundwater and be detected as far as 250 m from the operation. Not only can pathogenic resistant bacteria be transferred from animals to humans, but resistant genes can be transferred from bacteria of animals to human pathogens in human intestinal flora. Nitrate exposure has been found to correlate with birth defects and some cancers. An April 2003 assessment of water quality by the ISDA found that 69% of 22 wells in the Sunnyside area had $\text{NO}_3\text{-N}$ levels that exceeded the MCL (10mg/l) for drinking water, 80% were found to have nitrogen isotope composition values in the range indicating contamination from human or animal waste source.

-Batt, Angela, L.; Snow, Daniel D.; Aga, Dianna, S. "Occurrence of Sulfonamide Antimicrobials in Private Waster Wells in Washington County, Idaho, USA" Chemosphere 64, 2006.

- *Escherichia coli* O157:H7 isolates with multiple resistances were resistant to all but two antibiotics that target *E. coli* and are approved for feedlot animals. Resistance was found for six of eight (86%) of the antibiotics used to treat *E. coli* infections in feedlot animals. All isolates were resistant to tilmicosin, a commonly used feedlot antibiotic.
- Galland, John C.; Hyatt, Doreene R.; Crupper, Scott S.; Acheson, David W. "Prevalence, Antibiotic Susceptibility, and Diversity of *Escherichia coli* O157:H7 Isolates from a Longitudinal Study of Beef Cattle Feedlots" Applied Environmental Microbiology, Apr. 2001

- Air samples from swine CAFOs were collected and analyzed for the presence of antibiotic-resistant enterococci, gram-positive, catalase-negative cocci that are capable of causing a variety of animal and human infection. Resistance was tested against a variety of drugs that have been approved for swine productions for growth promotion, feed efficiency, and therapeutic purposes. It has been estimated that the nontherapeutic use of antimicrobials in livestock production makes up 60-80% of total antimicrobial production in the United States. Attention has been given to retail pork products as a source of human exposure to antibiotic-resistant bacteria. Results showed that 98% of the bacterial isolates that grew successfully during that antimicrobial susceptibility tests were resistant to high levels of at least two antibiotics commonly used in swine production (erythromycin, clindamycin, virginiamycin, or tetracycline); 93% of the isolates were resistant to at least 3 antibiotics. The types of bacteria detected in this study were *Enterococcus faecalis* and *E. faecium*, which have emerged as one of the leading causes of nosocomial bacterial infections, urinary tract infections, and wound infections in the U.S. The study suggests that the inhalation of air from swine CAFOs may serve as an additional environmental exposure for the transfer of multidrug-resistant bacterial pathogens from swine to humans.

-Chapin, Amy; Rule, Ana; Gibson, Kristen; Buckley, Timothy; Schwab, Kellogg. "Airborne Multidrug-Resistant Bacteria Isolated from a Concentrated Swine Feeding Operation" Environmental Health Perspectives vol. 113, no. 2, 2005
- Antibiotics are widely used in the swine industry to promote growth, prevent disease, and maintain production yields; in the current study, animals of the CAFO had received nontherapeutic doses of antibiotics 4 weeks before sampling. Feeding animals antibiotics is associated with the development of antibiotic-resistant bacteria within the animals. Individuals who live or work in proximity to a facility spreading antibiotic-resistant bacteria could face higher exposures to the organisms; at a local level, areas surrounding such CAFOs noticed a rise in the difficulty of treating human health problems. The total number of organisms found within the facility was 287 times high than the number found upwind of the facility. Multiple antibiotic resistance were present up to 150 m (the furthest distance measured) from the CAFO; the percentages were significantly higher than those recovered upwind. An estimated 17,000 of the 18,000 cfu/m³ released from the CAFO were defined as multidrug-resistant or multiple-antibiotic-resistant organisms because they were resistant to at least two classes of antibiotics; the air upwind contained an estimated 28 cfu/m³ that were multidrug-resistant. This demonstrates that people living near, or working in the facilities face a greater exposure to multidrug-resistant organisms, which could potentially affect human health.

-Gibbs, Shawn G.; Green, Christopher F.; Tarwater, Patrick M.; Motam Linda C.; Mena, Kristina D.; Scarpino, Pasquale V. "Isolation of Antibiotic-Resistant Bacteria from the Air Plume Downwind of a Swine Confined or Concentrated Animal Feeding Operation" Environmental Health Perspectives vol. 114, no. 7, 2006
- Antibiotics are widely used at therapeutic levels at CAFOs worldwide to treat animal diseases and promote weight gain. Such antibiotics are commonly excreted in urine, feces, and manure as parent compounds, conjugates, or oxidation and hydrolysis byproducts. It is estimated that as much as 75% of the administered antibiotics can pass through, and be excreted from the animal bodies. It has been reported that high levels of a number of commonly used antibiotics were detected in CAFO lagoons. Anaerobic lagoons can act as reservoirs of various antibiotics, and subsequently, lagoon bacterial populations may develop strong resistance to these antibiotics. Antibiotics were often found in surface and groundwater near CAFOs and where manure was applied as fertilizer. Seepage, runoff, and field application of the lagoon slurry may lead to contamination of surrounding surface

and groundwater with antibiotics and antibiotic resistant bacteria. The presence of antibiotics in the environment poses two potential risks. First, antibiotic select for resistant bacteria in livestock bodies; and second, the presence of antibiotic in streams, lakes and water supplies encourages the growth of resistant bacteria in humans and wildlife. A study was conducted to investigate the potential of free chlorine deposits into lagoon wastewater for decomposing antibiotics and inactivating bacteria. It was found that the bacteria population tends to rebound after an initial decrease in most cases, most likely due to the abundance of organic material and nutrients present. It was concluded that high chlorine doses are required to remove sulfonamide antibiotics from lagoon overflow prior to discharge into the environment. Such high doses however are likely to create high concentrations of chlorinated disinfection byproducts with potential environmental or human toxicity. Not using antibiotics for growth promotion at CAFOs may be the best way to reduce the release of antibiotics and antibiotic resistant bacteria into the environment.

-Qiang, Zhimn; Macauley, John, j.; Mormile, Melanie R.; Surampalli, Rao; Adams, Craig D. "Treatment of Antibiotics and Antibiotic Resistant Bacteria in Swine Wastewater with Free Chlorine". Journal of Agricultural and Food Chemistry 54, 2006

Section 7 —Negative Impacts on Communities

Background Information: The introduction of CAFOs into rural communities has significant economic downfalls. CAFOs shift unwanted burdens onto the community in the form of increased taxes and community costs such as health care, environmental, social and traffic expenses. The overall structure of communities decline with increased unemployment, and poverty, and decreased population, community involvement and real estate values.

- CAFOs tend to remove a higher percentage of money from rural communities than when the industry is dominated by smaller farm operations, which tend to circulate money within the community. Communities dominated by small owner-owned farms have a richer "civic and social fabric" with more retail purchases made locally and with income more equitably distributed. The concentration and industrialization of agriculture was associated with economic and community decline locally and regionally. Social and economic wealth being of local rural communities benefits from increasing the farmers, not the volume of the commodity produced.

Disproportionate location of CAFOs in areas populated by people with low incomes have negative impacts on the communities such as high susceptibility to CAFO impacts due to poor housing, low income, poor health status, and lack of access to medical care.

In 2005, the U.S. Government Accountability Office offered a report on the effectiveness of U.S. EPA efforts in meeting its obligations to regulate CAFOs. The report identified two major flaws: allowing an estimated 60% of CAFOs in the US to go unregulated, and the lack of federal oversight of state governments to insure adequately implemented federal regulations of CAFOs. 13 states in the US have enacted some form of law which inhibits citizens from freely speaking out against agriculture if it is disapproving. All 50 states have a form of right-to-farm legislation which protects farming operations from zoning laws or lawsuits that would overly restrict the ability of farmers to do business.

-Donham, Kelley J.; Wing, Steven; Osterberg, David; Flora, Jan L.; Hodne, Carol; Thu, Kendall M.; Thorne, Peter S. "Community Health and Socioeconomic Issues Surrounding Concentrated Animal Feeding Operation" Environmental Health Perspectives vol. 115, no. 2, 2007

- A study compiled by Linda M. Loba discussed the findings of over half a decade of research by herself and numerous colleagues. Roughly 3,000 U.S. counties were observed for community

well-being in relation to the presence of a CAFO. Lower incomes for segments of the community exhibited greater income inequality or greater poverty. Higher unemployment rates and lower total community employment was observed. Population decline was observed where family farms were replaced by CAFOs; also, social class structure became poorer. There were increases in crime rates and civil suits, increases in social conflict, and increased stress and social-psychological problems. Participation in community organizations declined, less democratic political decision-making was done, and the public becomes less involved in community affairs as outside CAFO business increases control over decision-making. Fewer retail trade and less diverse retail business. Real estate values declined in residences closest to the CAFOs relative to those more distant.

-Loboa, Linda M. "Industrialized Farming and Its Relationship to Community Well-Being: Report Prepared for the State of South Dakota, Office of the Attorney General." January 2000

- An Illinois State University study by Gómez and Zhang looked at 1,106 rural communities and found that economic growth rates were 55% higher in communities with traditional hog farms compared to those with large, industrialized hog farms. This was found in spite of the fact the economic growth rates were nearly identical prior to the introduction of the commercial hog farms. Data showed much higher population loss associated with increasing CAFOs and the authors suggest that without public policy to protect rural communities, a continuing decline of the community is at stake. A study by Hamed, Johnson, and Miller of the University of Missouri-Columbia found, based on averages of data collected, that land within three miles of a CAFO had decreasing values reaching approximately \$2.68 million (US) at approximately \$112 (US) per acre.

CAFOs are eligible for numerous tax write-offs because at times they are treated as industries, and at other times treated as farms; this creates a significant decrease in the amount of local taxes paid. At the same time, CAFOs cost the community greatly in health care, social, environmental, and traffic costs which the local government must finance, which forces them to rely on increased taxes, furthering a decrease in economic activity. Costs from CAFOs are also shifted and left for the community to clean up including groundwater contamination, air emissions, and the potential costs from pathogens, chemicals and antibiotics in manure.

-Weida, Dr. William J. "A Summary of the Regional Economic Effects of CAFOs" A Grace Factory Farm Project Report. July, 21, 2001

- Researches sought to assess the extent to which adolescents attending public schools may be exposed to swine CAFO emissions. Both record and survey-based exposure indexes were used, and racial and economic differences in potential exposure were examined. Seventh and eighth graders, as well as faculty, from 226 public schools in North Carolina participated in the survey designed to evaluate the prevalence of asthma-related symptoms during the 1999-2000 school year. The survey involved a 21-item survey about environmental health conditions inside and surrounding the school buildings. Distance between the schools and the nearest swine CAFO ranged from 0.2 to 42 miles; 66 schools were located within three miles of one or more operations. In 8% of the schools livestock odor was noticeable outdoors and indoors in 21% of the schools. Surveys indicated that the highest prevalence of noticeable odors outside or inside the school buildings were in schools with higher percentages of non-white and economically disadvantaged students. Reports of livestock odor raise concern not only about resulting health risks but also educational and behavioral consequences such as classroom disruptions, anxiety associated with the students' and faculty's inability to avoid the odor and concerns or precautions for students having a history of acute respiratory reactions.
- Mirabelli, Maria C.; Wing, Steve; Marshall, Stephen W.; Wilcosky, Timothy C. "Race, Poverty, and Potential Exposure of Middle-School Students to Air Emissions from Confined Swine Feeding Operations". Environmental Health Perspectives, vol. 114, no. 4 April 2006

