STATEMENT
ROBERT M. HIRSCH
ASSOCIATE DIRECTOR FOR WATER
U.S. GEOLOGICAL SURVEY
U.S. DEPARTMENT OF THE INTERIOR
BEFORE
UNITED STATES SENATE
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

September 6, 2007

Madam Chairman and Committee members, I appreciate the opportunity to appear before the Committee on Environment and Public Works to testify on the findings of U.S. Geological Survey (USGS) studies of water-quality issues related to Concentrated Animal Feeding Operations, commonly referred to as CAFOs.

As you may know, the mission of the USGS is to assess the quantity and the quality of the earth's resources and to provide information to assist resource managers and policy makers at the Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and research on the fate and transport of pollutants in water are important parts of the overall USGS mission.

USGS studies over the past 10 years have shown that CAFO impacts can include a wide variety of contaminants in many different environmental settings. The USGS and other organizations have investigated impacts from CAFOs that include the following: nutrients and their proximity to receiving waters that could cause hypoxia, harmful algal blooms, or contaminate drinking water sources; trace elements such as arsenic and copper that can contaminate surface waters and affect fish and aquatic plants; pathogens such as bacteria, viruses, and parasites; antibiotics that could foster the development of antibiotic-resistant pathogens; pesticides and hormones that can influence changes in fish reproductive capability; and solids from feed and feathers that could limit growth of desirable aquatic plants.

USGS research has centered on five major areas of investigation which are designed to track contaminants from their sources, through the environment, and to animal and human receptors: 1) analytical method development, 2) occurrence and relative source contributions of specific chemical and microbial contaminants and their mixtures, 3) pathways into and through the environment, 4) source fingerprinting, and 5) ecological effects. These areas of research are designed to provide scientific insights into potential public and ecological health impacts as well as provide management and policy decision makers with CAFO related information.

Analytical Method Development:

The first step in assessing potential environmental contamination from CAFOs is to anticipate and identify chemicals and microbes that are likely to be associated with CAFO wastes and effluents. USGS scientists continually develop new methods for identifying and quantifying veterinary medicines, naturally occurring hormones, pathogens, surfactants, and other

compounds which are not typically monitored in environmental settings but which are likely to be associated with a variety of sources including, non-confined animal production, CAFOs, and sewage treatment plants. Indeed much of our research related to CAFO impacts on the environment thus far has focused on analytical method development for a range of these potential contaminants in various environmental matrices including water, sediment, and animal tissue.

Occurrence and Relative Source Contributions:

Because environmental contaminants have many sources, the USGS is quantifying relative contributions and types of environmental contaminants originating in CAFO wastes. The intent is to understand environmental contaminants that are specific to CAFO operations.

CAFOs can be sources of nutrient introduction to the environment. Around the Nation, the USGS finds that relative to other sources (atmospheric sources, synthetic fertilizers, or point source nitrogen), manures were shown to be the single largest source of nitrogen for some rivers, such as the Susquehanna (PA), Altamaha (GA), Apalachicola (FL), White (AR), San Joaquin (CA), and the Fox (WI). Manures are the second largest source of nitrogen for the Potomac (VA, MD), Trinity (TX), Rio Grande (NM), Snake (ID), Platte (NE), and Willamette (OR). In the Neuse River Basin of North Carolina, we have found that nitrogen concentrations in ground waters near or under areas treated with liquid swine waste tend to be higher than areas treated with synthetic fertilizers. After 4 years of application, nitrogen concentrations from swine waste increased by 3.5 times in shallow ground water compared to concentrations prior to application, and median nitrate concentrations were about double from swine spray applications compared to commercial fertilizer. In Oklahoma, shallow monitoring wells were tested around CAFO hog operations from the central part of the State to the northwest, and these monitoring wells indicated considerably higher nitrate concentrations than for monitoring wells away from CAFO installations. For 79 wells sampled in 2001, median nitrate concentrations in wells affected by animal operations were near 30 mg/L versus about 15 mg/L for wells mostly affected by fertilizer applications. These studies indicate a substantial influence from CAFO operations on nitrogen concentration in the underlying aquifer, and although the wells tested were not used for drinking water, the U.S. Environmental Protection Agency drinking water nitrate standard of 10 mg/L was exceeded.

A study conducted in the Stillwater Basin in Ohio examined runoff from agricultural fields for a variety of contaminants. The study showed that veterinary antibiotics, particularly lincomycin (detected in 23 percent of samples), were present more frequently in streams draining watersheds with the highest animal density. Antibiotics introduced to the environment from the many CAFO type operations are of interest because of their potential for causing antibiotic-resistant bacteria to proliferate. In a reconnaissance water sampling of fish hatcheries in 7 States from 2001 to 2003, the USGS found aquaculture-approved antibiotics at low concentrations in about 15-30 percent of samples from hatchery water.

The USGS conducted a study near a National Wildlife Refuge in Nebraska to determine the impacts of swine operations on fecal bacteria occurrence. For the area near hog operations in Nebraska, we found that the CAFO was a potential source of zoonotic bacterial pathogens like

salmonella. Wetlands created from swine waste-water effluent had 5-50 fold greater concentrations of phosphorus, ammonia, and total nitrogen, and 2-3 fold greater salinity compared to control sites. *Cyanobacteria* were abundant in the created wetlands and *microcystin* toxins were also detected in three of six wetlands sampled water samples.

CAFO operations may also be sources of metals like copper and arsenic. Often these metals are used as feed amendments to enhance animal growth. Organic arsenic feed additives are used in poultry production for increasing weight gain, improving feed efficiency and pigmentation, and controlling bacterial and parasitic disease. The USGS has done reconnaissance for arsenic on the Delmarva Peninsula in areas dominated by poultry production. From our examination of storm water, soil water and shallow ground water, it is evident that some arsenic from poultry operations is released to the environment because concentrations in fresh poultry litter were about 10 times the concentrations found in soil of the area. Concentrations in most samples in the Delmarva were generally below the drinking water standard of 10 µg/L (parts per billion).

USGS water-quality research continues to show that contaminants in water resources seldom occur alone and more commonly occur in mixtures with other contaminants, including combinations of naturally occurring or man-made inorganic, organic, or microbial contaminant groups. These mixtures sometimes originate from similar sources but often come from varied sources contributing contaminants to our watersheds and aquifers

Pathways into and through the environment:

CAFO wastes can enter the environment directly though leaching under lagoons, ditching, or other direct hydraulic connections or they can enter indirectly when solid and liquid wastes are removed from CAFOs and applied to land elsewhere as nutrient and soil amendments. Once in the environment, various properties of chemical and microbial contaminants as well as interactions with ambient conditions will determine their movement and behavior. For example, some contaminants have a natural affinity to attach to soils or organic material and therefore tend to be sequestered close to the sources of contamination while others readily dissolve in water and may move long distances from the introduction location. The type of soil, amount of organic material, and indigenous bacterial populations it contains may facilitate or retard the movement of various contaminants.

In one study around hog operations in Iowa where tetracycline was used, we did not find the antibiotic in the ground water or even the lagoon berm, probably because tetracycline is known to sorb to solids and the area soil is rich in organic matter. In contrast near a hog operation in North Carolina where both tetracycline and sulfamethazine are used, tetracycline was not found in monitoring wells near the lagoons, but the sulfamethazine was found. Sulfamethazine is known to be much more mobile in water than tetracycline.

Poultry litter is applied to croplands in the North Carolina coastal plain as a nutrient source, as it is in many areas across the Nation, and the application increased shallow ground-water concentrations of nitrogen more than synthetic fertilizer applications in the vicinity. This is an important finding because synthetic sources of nitrogen are typically applied in readily available

forms to plants as opposed to manures, which require additional natural processing after application and likely remain in the soils for longer periods of time. Therefore the time between animal fertilizer application and when their nutrients become available to plants dictates the volume needed as well as timing of application, and understanding these factors will be crucial to finding effective management solutions. In contrast to the North Carolina study, however, USGS research in southwestern Missouri, where poultry operations are also concentrated, did not find that nitrogen concentrations increased in shallow ground water after several years of poultry litter application was used as a soil amendment. These differences likely represent soil and geohydrologic property differences between the two areas studied and the time period over which the studies were conducted. The results suggest that it is difficult to make broad generalized statements about CAFO impacts to the environment from these studies of limited geographic and temporal scope.

Movement of contaminants in CAFO waste also depends on farm operations and local environmental conditions, and may reflect the hydrologic or precipitation conditions at time of sampling. In addition, hormones and other chemicals are excreted in a changed or transformed form after being metabolized by animals and therefore have different toxicological, chemical, and physiological characteristics than before they are metabolized. Waters draining land where animals have been raised on pasture and not subject to CAFO finishing will likely have unique chemical signatures. These differences in water chemistries must be understood in context with the individual species of animals raised in CAFOs as compared with their pastured counterparts in order to understand contaminant issues unique to CAFO management procedures. All these factors along with the many sources of waste products from human and animal activity contribute to wide variation in environmental conditions at or near CAFO operations.

Source Fingerprinting:

In addition to development of laboratory analytical methods for specific contaminants, the USGS is focusing on development of "source-fingerprinting" or "source-tracking" techniques to identify various waste, and other, sources of environmental contaminants. These efforts include genetic as well as chemical and microbial approaches but all share the common objective of identifying one or a few chemicals/microbes which, when detected in environmental waters, can be unambiguously traced back to a unique contaminant source.

As mentioned before, there are many varied sources of nitrogen to the environment and therefore we believe it is important to determine the different sources of nitrogen in surface and ground waters. The USGS is developing tools to identify sources of nitrogen from CAFOs using nitrogen isotopes and elements such as calcium, magnesium, sodium and potassium. In test wells located in fields sprayed with swine waste, concentrations increased after spraying by 2 to 4 times for many elements and an isotope of nitrogen (nitrogen-15), thereby indicating that the source of contamination was the swine waste.

Because CAFO areas can be an important source of bacteria and other pathogens, and the antibiotics from these areas can lead to antibiotic resistant bacteria, the USGS has been developing microbial source tracking methods to determine pathogen contamination of environmental waters associated with livestock sources. The approach is to distinguish the

origins of gut microbes based on source-specific characteristics such as individual species that are host specific, like *bacteroides* found only in humans and therefore indicative of human waste sources, or bacteria populations resistant to antibiotics commonly used by humans versus other animals, or looking for genetic markers that indicate specific host-microbe interactions. While advances in these methods have been made in recent years, microbes are most often found in complex mixtures of waters from many waste sources originating from animals exposed to various food and other sources of chemicals and microbes. These, and other complexities, produce ambiguous results even within organism specific identification procedures.

In one study on biosolids applications in agricultural fields in Colorado, molybdenum and tungsten, and to a lesser degree antimony, cadmium, cobalt, copper, mercury, nickel, phosphorus, and selenium, were determined the most likely inorganic indicators of chemical migration from biosolid applications on land to ground water or surface water. Other approaches have included indicators that occur infrequently in nature but are associated with specific uses and waste sources. While these fingerprinting techniques are not yet fully developed, they will soon be used alone or in conjunction with each other to enable the unambiguous distinction between contaminants coming from CAFOs and the many other potential sources of specific contaminants. This capability will be crucial for management and policy decisions unique to CAFO sources of environmental contamination.

Ecological Effects:

Because most USGS research thus far has focused on methods development and occurrence activities we are still in the beginnings of investigating potential ecological health effects of CAFOs. USGS research is focused on individual as well as community-level ecological health issues such as eutrophication/hypoxia of nearby waters, diseases from pathogens, antibiotic resistance, and endocrine disruption.

Preliminary results have shown that fecal indicator bacteria counts in surface waters downstream of hog operations in Nebraska have exceeded Federal concentration standards for contact recreation, and the majority of bacterial isolates tested were resistant to at least one antibiotic, usually tetracycline. Initial results from the study in Nebraska near a National Wildlife Refuge indicate that impacts to created wetlands from nearby hog operations could pose a threat to waterfowl health due to pathogen exposure. In Oklahoma near cattle and hog operations, the findings were similar and although bacteria concentrations in Oklahoma were generally lower, they have exceeded Federal standards for contact recreation. In addition, resistance to antibiotics used in animal agriculture was common among fecal indicator organisms found in the Oklahoma study, especially gram positives, which includes many well-known genera such as *Bacillus*, *Listeria*, *Staphylococcus*, *Streptococcus*, *Enterococcus*, and *Clostridium*.

Information from studies in the literature and preliminary studies by USGS have guided us to focus future CAFO research on the spread of antibiotic resistance and the effects of hormonally active chemicals.

Summary:

The USGS has found CAFOs to be a source of nutrient, pharmaceutical, and metal contaminants in nearby waters and lands receiving wastes. Additional research is needed to determine the relative source contributions and environmental behavior of contaminants originating from a range of animal and land-use operations to make scientifically credible management and policy decisions specific to CAFOs. Identification of sources and movement of waste contaminants requires more research on degradation and metabolic products from the many compounds used in animal agriculture, especially pharmaceuticals in various feed mixtures, therapies, and environmental settings. Some potential ecological effects have been hypothesized and are currently under investigation, including the role of CAFOs in eutrophication of receiving waters, wildlife exposure to pathogens and endocrine disruptors, and development of antibiotic resistance. .

I appreciate the opportunity to testify on the results of USGS assessments and research on CAFOs. I am happy to respond to any questions from the Committee.

References

http://water.usgs.gov/owq/AFO/index.html

http://toxics.usgs.gov/topics/lab_methods.html

http://toxics.usgs.gov/regional/emc/sources_pathways.html

http://oh.water.usgs.gov/micro_sourcetracking.htm

http://toxics.usgs.gov/regional/emc/source_characterization.html.

Barber, L.B., Lee, K.E., Swackhamer, D.L., Schoenfuss, H.L., 2007, Reproductive responses of male fathead minnows exposed to wastewater treatment plant effluent, effluent treated with XAD8 resin, and an environmentally relevant mixture of alkylphenol compounds: Aquatic Toxicology, v. 82, no. 1, p. 36-46, doi: doi:10.1016/j.aquatox.2007.01.003. http://toxics.usgs.gov/highlights/wastewater_fish.html

Becker, M.F., K.D. Peter, and J. Masoner. 2002, Possible Sources of Nitrate in Ground Water at Swine Licensed-Managed Feeding Operations in Oklahoma, 200. USGS WRIR 02-4257. http://pubs.usgs.gov/wri/wri024257

Campagnolo, E.R., Kammy R. Johnson, Adam Karpati Carol S. Rubin, Dana W. Kolpin, Michael T. Meyer, J. Emilio Esteban, Russell W. Currier, Kathleen Smith, Kendall M. Thu and Michael McGeehin . 2002, Antimicrobial residues in animal waste and water resources proximal to large-scale swine and poultry feeding operations. Science of the Total Environment, Vol 299, 1-3, pp. 89-95. http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V78-46X2M47-1&_user=10&_coverDate=11%2F01%2F2002&_rdoc=7&_fmt=summary&_orig=browse&_sort=d&wchp=dGLbVzb-lSztb&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=625e06f6dd3c38aad17973cfd767970c

Christian, Thorsten, Schneider, R.J., Farber, H.A., Skutlarek, Dirk, Meyer, M.T., Goldbach, H.E., 2003, Determination of antibiotic residues in manure, soil, and surface waters: *Acta hydrochim. hydrobiol.* V. 31, p. 36-44.

Denver, J.M., et.al., 2004, Water Quality in the Delmarva Peninsula, Delaware, Maryland, and Virginia, 1999-2001: U.S. Geological Survey Circular 1228, 30 pages. [The relevant pages are 20-21. The Rice report above is a supporting document, but the information here is from the Circular.] http://pubs.usgs.gov/circ/2004/1228/

Dietze, J.E., Scribner, E.A., Meyer, M.T., and Kolpin, D.W., 2005, Occurrence of antibiotics in water from 13 fish hatcheries, 2001-2003: International Journal of Environmental and Analytical Chemistry, v. 85, no. 15, p. 1141-1152.

Fogarty, L.R., and Voytek, M.A., 2005, Comparison of *Bacteroides-Prevotella* 16S rRNA genetic markers for fecal samples from different animal species: Applied and Environmental Microbiology, v. 71, no. 10.

Mugel, Douglas N., 2002, Ground-water quality and effects of poultry confined animal feeding operations on shallow ground water, upper Shoal Creek basin, Southwest Missouri, 2000: U.S. Geological Survey Water Resources Investigations Report 2002-4125, 41 p. http://mo.water.usgs.gov/Reports/WRIR02-4125/

Rice, K.C. M.M. Monti, M.R. Ettinger, 2005, Water-Quality Data from Ground- and Surface-Water Sites near Concentrated Animal Feeding Operations (CAFOs) and non-CAFOs in the Shenandoah Valley and Eastern Shore of Virginia, January-February, 2004. USGS OFR 2005-1388. http://pubs.usgs.gov/of/2005/1388/

Rowe, G.L., D.C. Reutter, D.L. Runkle, J.A. Hambrook, S.D. Janosy, L.H.Hwang, 2004, Water quality in the Great and Little Miami River Basins Ohio and Indiana 1999-2001. USGS Circular 1229. http://pubs.usgs.gov/circ/2004/1229/

Ruddy, Barbara C., Lorenz, David L., Mueller, David K., 2006, County-level estimates of nutrient inputs to the land surface of the conterminous United States, 1982-2001, U.S. Geological Survey Scientific Investigation Report, 2006-5012, 17 p.

Sarmah, A.K., Meyer, M.T., Boxall, A.B.A, 2006, A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment**,** *Chemosphere* 65 (5), pp. 725-759.

Schumacher, J.G. 2003. Survival, Transport, and Sources of Fecal Bacteria in Streams and Survival in Land-Applied Poultry Litter in the Upper Shoal Creek Basin, Southwestern Missouri, 2001–2002. USGS WRIR 03-4243. http://mo.water.usgs.gov/Reports/wrir03-4243-schu/report.pdf

Schwarz, M.S., K.R. Echols, M.J. Wolcott, K.J.Nelson, 2004. Environmental contaminants associated with a swine concentrated animal feeding operation and implications for Mcmurtrey National Wildlife Refuge. USFWS DEC ID: 6N45 FFS 200060006. http://www.fws.gov/mountain-prairie/contaminants/papers/Hastings%20Pork%20CAFO%2000%20final%20report.pdf

Spruill, T.B., A.J. Tesoriero, H.E. Mew, Jr., K.M. Farrell, S.L. Harden, A.B. Colosimo, and S.R. Kraemer, 2004, Geochemistry and Characteristics of Nitrogen Transport at a Confined Animal Feeding

Operation in a Coastal Plain Agricultural Watershed, and Implications for Nutrient Loading in the Neuse River Basin, North Carolina, 1999–2002. USGS SIR 2004-5283 http://pubs.usgs.gov/sir/2004/5283/

U.S. Geological Survey, 1999, The Quality of Our Nation's Waters: Nutrients and Pesticides. USGS Circular 1225. http://pubs.usgs.gov/circ/circ1225/pdf/front.pdf

Yaeger, J.B., D.B. Smith, and J.G. Crock. 2004, Biosolids, Soil, Crop, Ground-Water, and Streambed-Sediment Data for a Biosolids-Application Area Near Deer Trail, Colorado, 2001. USGS OFR 2004-1388. http://pubs.usgs.gov/of/2004/1388/