USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

RESEARCH PROPOSAL

(1) Project Title: **Environmental and Human Health Impact of Swine Waste Management Practices**

(2) Focus Categories: AG, NPP, WW

(3) Keywords: Soil Microbiology, Soil Chemistry, Nitrogen, Animal Waste, Fertilizer, Pathogens, Viruses, Lagoons

(4) Duration: 1 September 1998 - 31 August 1999

(5) Federal Funds Requested:

(6) Non-Federal (Matching) Funds Pledged:

(7) Principal Investigators: Stephen C. Whalen and Mark D. Sobsey

University of North Carolina

Chapel Hill, NC 27599-7400

North Carolina Water Resources Research Institute

(8) Congressional District of University Performing Research: 4th

(9) Statement of the Critical Regional Water Problem:

Nationwide, agriculture is the most important nonpoint source polluter (Sharpley and Meyer 1994). The swine industry is an increasingly important agricultural sector in the Southeastern United States. Rapid regional industry expansion has been accompanied by a shift from family farms to industrial scale animal production in confined quarters. This unprecedented growth presents enormous challenges with regard to disposal of swine manure. For example, swine waste production in North Carolina alone is 8 Tg yr^{-1}, which includes 48 Gg N (Crouse 1995). Regionally, waste is commonly stored in anaerobic lagoons and the liquid phase is land-applied as fertilizer at no more than the agronomic nutrient (in this case N) requirement for the host crop. Improper management may encourage offsite transport, leading to enhanced N loading in adjoining ecosystems, particularly N-sensitive rivers, estuaries and coastal waterways. Clearly, agricultural water quality priorities relative to disposal of swine waste must include development and implementation of Best Management Practices (BMPs) and land use policies that both minimize loss of plant-available N from the site of application and meet the nutritional N requirements of the host crop. This is best accomplished through comprehensive studies that encompass of all aspects of N cycling dynamics in spray fields, including simultaneous analysis of changes in pool sizes and rates of microbial and plant N transformations. Regional information of this nature is lacking.

Traditional BMPs for agricultural animal wastes have focused primarily on nutrients. However, it is now recognized that these waste materials can harbor numerous enteric human pathogens that will

contaminate the environment and pose a human health risk if not properly managed. In particular, the protozoans *Cryptosporidium parvum* and various species of *Salmonella* bacteria are present in hog waste. These pathogens have been responsible for numerous outbreaks of gastrointestional illness caused by contaminated drinking water (MMWR 1996). Although *Cryptosporidium*, *Salmonella* and other human pathogens of animal origin are widespread in animal wastes, little is known about the relative contribution of agricultural animal wastes to environmental contamination of water resources. On a more basic level, even less is known about the effectiveness of waste treatment systems such as anaerobic lagoons in reducing pathogens or microbial indicators of fecal contamination. In order to better characterize the potential risks to human health and to identify appropriate and appropriate regional (BMPs), information is needed on: (a) the occurrence, survival and treatment or *Cryptosporidium*, *Salmonella* and other human pathogens in stored hog waste: and (b) the effectiveness of current and candidate waste treatment processes at removing and destroying these pathogens before they are discharged into the environment.

This two part proposal is aimed at: (a) obtaining a comprehensive N mass balance for liquid swine effluent applied seasonally to mesoscale (4m X 4m) experimental plots at different loading rates to determine the relative importance and relevant time scales for physical (NH_3 volatilization, leaching) and biological (plant and microbial activities) processes involved in N transformations and transfers among reservoirs; and (b) characterizing and quantifying the reductions of pathogens and microbial indicators by conventional and alternative treatment systems for swine waste. These objectives are directly responsive to the several target areas of the 1998 Regional Water Resources Competitive Grants Program (Southeast and Island Region), namely "problems from non-point sources of both municipal and agricultural sources ", "use and user impacts on water quality", and "water quality problems associated with eutrophication and weed control".

(10) Statement of Results, Benefit and/or Information Expected:

One aspect of the proposed research will seasonally examine the event-scale (single application), near-term fate of liquid lagoonal swine effluent applied to experimental spray field plots at three representative loading rates. Changes in N pool sizes and rates of physical (NH_3 volatilization, leaching) and biological (plant uptake, microbial activity) processes that mediate transfers among pools or effect loss from the active soil zone will be assessed for a two week post-fertilization period during experiments conducted in the spring, summer, fall and winter. A nitrogen mass balance will be developed where all flux terms and pool sizes will be determined such that an error of closure can be assessed. This comprehensive analysis will yield the first event-scale conceptual understanding of the fate of fertilizer N following field application. Although the goal of fertilization is efficient plant N assimilation, there is considerable speculation that a significant fraction of the effluent is lost to NH_3 volatilization and possibly denitrification. This study will give initial insight into the relative importance of these and other loss terms on an event basis (single fertilization). Further, the experimental design will give insight into the location of soil zones active in microbial N processing and the time trajectory for microbial activities associated with N transformations following a fertilization event. Finally, this study will give information regarding changes in rates and relative importance of various microbial N transformations and changes in the relationship between physical and biological processes in mediating N loss from the soil as a function of season and effluent loading rate. Intelligent waste management decisions require a comprehensive understanding of N cycling dynamics in spray fields at all time scales. These data are presently lacking. Consequently, at state and regional levels, results of this aspect of the study will be useful to swine waste operation managers and soil management and water quality agencies in: (a) assessing the effectiveness of present guidelines (BMPs) for land application of animal wastes; and (b) making informed decisions regarding modification of extant BMPs.

A second aspect of the proposed research will produce definitive information on the occurrence (prevalence and concentrations) of *Cryptosporidium*, *Salmonella* and perhaps other human pathogens and candidate microbial indicators of these pathogens in raw, treated and stored hog wastes. These data will characterize the extent to which hog wastes pose a risk to the environment and to human health if the pathogens are not adequately reduced by waste treatment practices. This aspect of the proposed research will provide quantitative data on the rate and extent of reduction of *Cryptosporidium* and *Salmonella* and

their candidate microbial indicators in current and alternative swine waste storage and treatment processes. These data will provide quantitative information on the potential for stored and treated hog waste to contaminate nearby surface and ground waters when discharged into the environment. Further, these data will provide a firm basis to determine the risks to human health from *Cryptosporidium*, *Salmonella* and other pathogens of hog waste origin in waters used for various beneficial purposes (drinking water supplies, primary contact recreation and shellfishing). The information from this aspect of the proposed research will provide the basis for evaluating the effectiveness of current and candidate swine waste treatment , storage and disposal practices as well as the effectiveness of alternative technologies to treat swine waste for pathogen reduction, and the potential for these processes to serve as BMPs.