

*Proposal for*

**Characterization of Surface-Water Quality Associated with  
Swine CAFOs in Eastern North Carolina**

*Submitted to*

**North Carolina Department of Environment and Natural Resources  
Division of Water Quality**

*prepared by*

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## Table of Contents

Background.....	- 3 -
Problem .....	- 4 -
Objectives .....	- 4 -
Scope .....	- 6 -
Relevance and Benefits .....	- 7 -
Approach .....	- 7 -
Task 1. Develop representative network of stream sampling sites that contain permitted swine CAFOs	- 9 -
Task 2. Collect surface-water samples from sites included in the sampling network for laboratory analysis of nutrients and ions .....	- 9 -
Sample collection strategy .....	- 9 -
Constituents .....	- 10 -
Data collection techniques .....	- 11 -
Task 3. Conduct an analysis and summary of the data collected during the study .....	- 11 -
Quality Assurance .....	- 12 -
Products.....	- 13 -
Personnel.....	- 14 -
Project funding and timeline .....	- 14 -
References .....	- 16 -

## Background

In eastern North Carolina, excessive nutrient loadings have contributed to the degradation of surface-water quality in the Neuse and Tar-Pamlico River basins, particularly in the estuaries (Gilliam and others, 1997; Spruill and others, 1998; Luettich and others, 2000; Burkholder and others, 2006). Nonpoint sources are recognized as a major contributor of pollutants to North Carolina's coastal sounds. Agricultural activities and urban runoff are among the leading sources of nonpoint-source pollutants, such as nutrients and sediment. The EPA's 2002 National Water Quality Inventory (United States Environmental Protection Agency, 2002) indicated that microbial water quality is a leading cause of impairment in many surface waters, and that agricultural activities, including concentrated animal feeding operations (CAFOs), are the most common polluters of rivers and streams, contributing to the impairment of 37% of those surveyed.

In 1997, the North Carolina Environmental Management Commission (EMC) adopted rules to reduce nitrogen loads to the Neuse River by 30 percent to support the Neuse River Nutrient Sensitive Waters (NSW) Management Strategy (North Carolina Division of Water Quality, 2010a). Similarly, the EMC adopted rules during 2000 and 2001 for the Tar-Pamlico River basin to reduce nitrogen loads by 30 percent and to control phosphorus loads at or below 1991 levels (North Carolina Division of Water Quality, 2010b). The NSW Management Strategy implemented for the Neuse River basin includes a total maximum daily load (TMDL), point source discharge requirements, agricultural loading reduction requirements, stormwater management rules, riparian buffer protection rules, and other rules intended to reduce nutrient loading to the Neuse estuary. A similar NSW management strategy has been adopted for the Tar-Pamlico. According to the July 2009 Neuse Basinwide Plan (Chapter 24; <http://h2o.enr.state.nc.us/basinwide/Neuse/2008/NeuseRiverBasinPlanDRAFT.htm>), individual categories of nutrient sources (such as point source discharges and agriculture) have met their respective goals for nutrient reductions; however, monitoring data indicate that the overall goal of 30% reduction of nutrient loading to the Neuse estuary has not been achieved, and impairments in the estuary have expanded.

Developing and implementing water-quality restoration plans for impaired watersheds in the North Carolina Coastal Plain requires an understanding of the potential influence that different agricultural nonpoint sources may have on nutrient transport to receiving streams. North Carolina is the second highest swine producing state in the Nation (United States Department of Agriculture, 2009), and as such, there is significant interest in understanding the extent to which swine CAFOs may influence water-quality conditions, especially in eastern North Carolina. The potential for CAFOs to contaminate both surface- and groundwater has been well established, as described in Burkholder et al. (2007). Potential contaminants from swine CAFOs include nutrients, bacteria and many emerging contaminants, which include antibiotics and steroids that can act as endocrine disruptors. Several studies conducted in eastern North Carolina have indicated that nutrients associated with swine CAFOs have influenced water-quality conditions in surface water and groundwater (Stone et al., 1995; Gilliam et al., 1996; Karr et al., 2001; Harden and Spruill, 2004; Tesoriero et al., 2005; Harden and Spruill, 2008). These studies conducted to evaluate offsite nutrient transport from swine CAFOs to receiving streams have been limited in geographic extent, either focusing on individual farm sites or several farms within a small watershed. Additional data are needed from a larger number of sites over a broader geographic area to better understand whether swine CAFOs influence stream water quality in eastern North Carolina.

In 2007, the EMC received petitions seeking the development of rules to assess potential water quality impacts from CAFOs. In 2008, the EMC approved the petitions and directed the North Carolina Division of Water Quality (DWQ), with input from various stakeholder groups, to develop rules to establish and implement a surface water monitoring program addressing the petitioners concerns. Proposed rules (15A

NCAC 02T .1310-.1311; accessible at <http://portal.ncdenr.org/web/wq/aps/afo/news-updates/water-quality-monitoring-petition>) were developed that defined the process for establishing sampling locations at each subject animal operation, sampling frequency and water quality parameters to be evaluated. These rules went to public hearing in May – July 2009.

The Animal Feeding Operations Unit within DWQ is responsible for permitting and regulating animal feeding operations throughout North Carolina. As of 2010, DWQ permitted approximately 2,150 swine operations in the state, the majority of which are located in the Coastal Plain Physiographic Province (fig. 1). The lack of stream water-quality data from a more representative number of permitted swine CAFOs makes it difficult for DWQ to assess the extent to which effects of swine CAFOs on stream nutrient concentrations can be measured, how well existing CAFO regulations protect the waters of the state, or to recommend effective changes to regulations or procedures. Therefore, to better understand potential effects of swine CAFOs on surface-water nutrients, the proposed study will aim to develop and implement a sampling strategy to characterize stream nutrient concentrations associated with a representative subset of permitted swine CAFOs located in the North Carolina Coastal Plain.

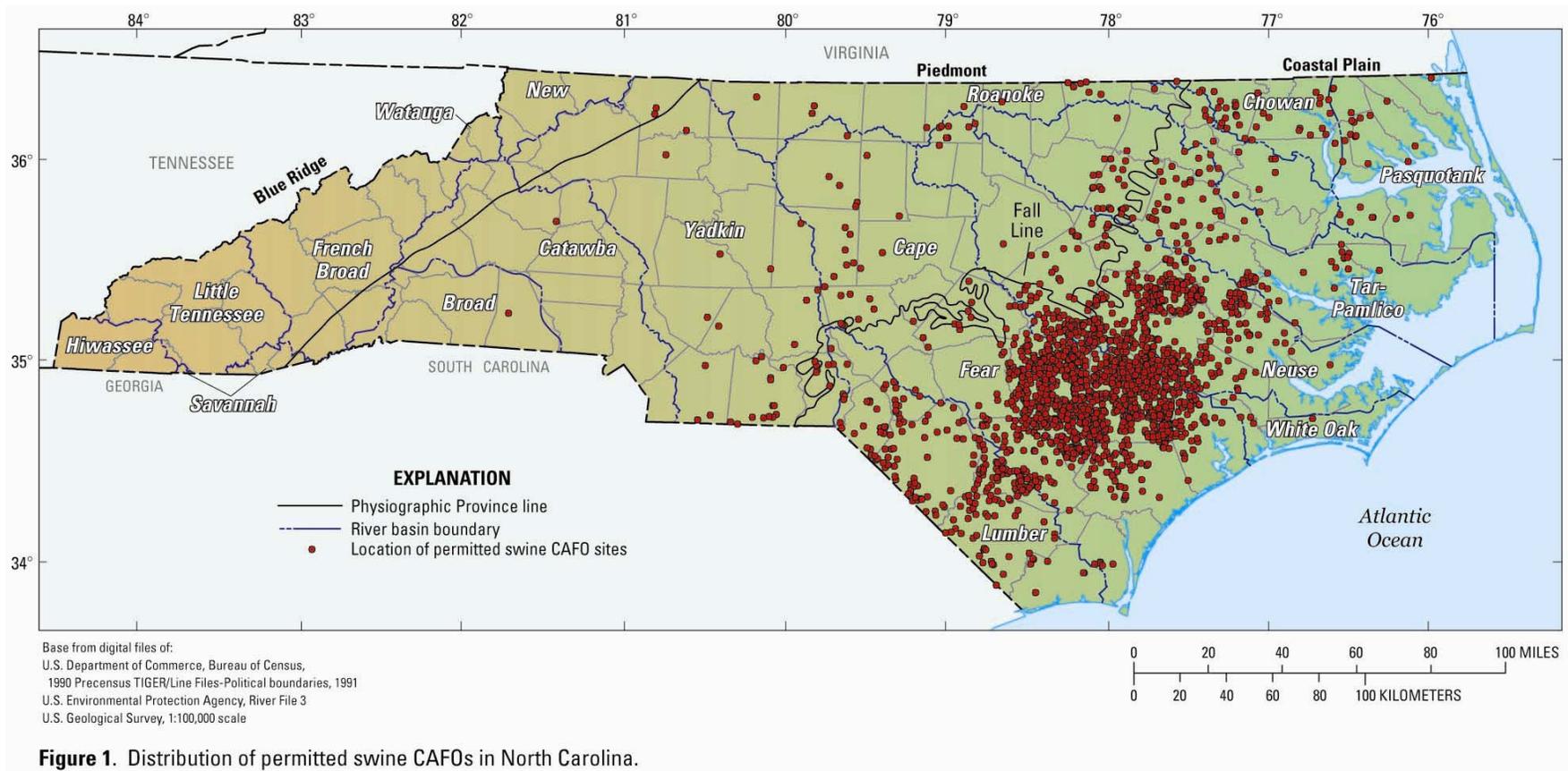
## **Problem**

The practice of applying waste manure from swine CAFOs to agricultural fields is commonplace throughout the North Carolina Coastal Plain. In 2010, DWQ permitted approximately 2,150 swine operations in North Carolina, most of which are in the Coastal Plain. Research indicates that swine CAFOs have been shown to influence nutrient delivery to streams on small-scale site-specific studies; however, the overall impact to surface waters throughout the Coastal Plain is largely unknown. The lack of stream water-quality data associated with a large number of permitted swine CAFOs makes it difficult for DWQ to assess how well existing regulations protect the waters of the State or to even recommend effective changes to regulations or procedures.

## **Objectives**

The proposed cooperative research between USGS and DWQ has an overall goal of generating needed information to provide a scientific basis for water-resource managers and policy makers to evaluate existing, or establish new, regulations or procedures at permitted swine CAFOs for protecting and enhancing stream water quality in nutrient impaired waters in eastern North Carolina. The primary objective of this investigation is to initiate a water-quality sampling study to characterize stream nutrient concentrations associated with swine CAFOs in the Coastal Plain of North Carolina. These CAFOs will be representative of the approximately 2,000 swine CAFOs permitted by DWQ that are located in the Coastal Plain (fig. 1).

It is understood that many environmental factors influence the quantity of nutrients delivered to Coastal Plain streams. Some important factors include differences in nutrient contributions from both point and nonpoint sources of nutrients, land use, soil types, best management practices (BMPs), hydrogeologic setting, storm-water runoff, groundwater discharge, and geochemical processes. The proposed study is not intended to evaluate relative contributions of different nutrient sources or transport mechanisms and geochemical processing that influence the overall amounts of nutrients delivered to streams having swine CAFOs.



The proposed project will attempt to document whether swine CAFOs located in Coastal Plain watersheds have a measurable effect on surface water nutrient concentrations. Part of the study focus will be to evaluate groupings of swine CAFOs based on site attributes (such as density of swine animals, balance of plant available nitrogen (PAN) at farm, size of waste application fields, or presence of tile drainage) to examine potential correlations between CAFO site characteristics and stream nutrient concentrations. These correlations may be useful for identifying common characteristics associated with swine CAFOs when measured effects on stream nutrients are observed, and thus, providing information to support development of strategies intended to reduce potential nutrient loadings from swine CAFOs to receiving streams. The proposed study primarily focuses on nutrients because of ongoing efforts to improve water-quality conditions in nutrient sensitive waters in the North Carolina Coastal Plain. Data for other water-quality constituents including field parameters and selected major ions will be collected and used to characterize potential effects of swine CAFOs on surface-water quality.

The objectives for this investigation are as follows:

- Develop a subset of the 2,150 permitted swine CAFOs in North Carolina for use in water-quality sampling that are representative of swine CAFOs located in the Coastal Plain;
- Measure and compare stream concentrations of nutrients and select ions in streams and watersheds containing swine CAFOs grouped on the basis of site operational or environmental attributes;
- Analyze and summarize the data to characterize potential impacts of swine CAFOs on receiving surface water.

## Scope

This study will be conducted by the USGS in cooperation with DWQ. The proposed work will include collection of field water-quality parameters and -samples for laboratory analysis of nutrients (dissolved nitrite plus nitrate, dissolved ammonia, total ammonia plus organic nitrogen (N), and total phosphorus) and dissolved ions (chloride, sodium, and potassium) in various streams with swine CAFOs throughout eastern North Carolina. The scope of work for this proposal extends over a 3-year period, beginning in July 2011 and ending in June 2014. Selection of study sampling sites and field data collection activities will be conducted during the first two years. Given that there are over 2,000 permitted swine CAFOs in North Carolina, it is impractical to sample all swine facilities based on available financial and personnel resources. Compilation of chemical data necessary for better understanding whether effects of swine CAFOs on surface-water quality can be measured will first require selection of a subset of the permitted swine CAFOs for use in data collection and analysis. Available site attribute information for the permitted CAFOs (such as number of animals, PAN balance, size of waste application fields, and presence of tile drains) will be used with GIS analysis for developing a network of sampling sites that 1) can feasibly be sampled given available resources, and 2) is representative of swine CAFOs found in the Coastal Plain. Subsequent to developing the network of sampling sites, water-quality samples will be collected from each site for laboratory analysis of nutrients and ions. Statistical analyses will be conducted to determine if there are significant differences in measured nutrient concentrations at the stream study sites and to examine potential correlations between CAFO site attributes and stream nutrient concentrations. In the final year of the project, the USGS will develop a final project report that presents and evaluates the study results.

## Relevance and Benefits

This investigation of the influence of swine CAFOs on surface-water quality supports 3 of the 6 USGS strategic science directions (U.S. Geological Survey, 2007):

1. Understanding ecosystems and predicting ecosystem change—this science direction is designed to study “the causes and consequences of ecological change” and to monitor “biological and physical components . . . of ecosystems.”
2. The Role of Environment and Wildlife in Human Health – this science direction is focused on providing the “scientific and monitoring information essential for helping to identify existing, emerging and resurging environmental and ecosystem health threats.”
3. A water census for the United States—the water census is designed to, among other things, provide information and forecasts “of likely outcomes for water availability, water quality and aquatic ecosystem health caused by changes in land use and land cover . . . [and] natural and engineered infrastructure.”

In support of the USGS Water Resources Mission (<http://water.usgs.gov/mission.html>), the proposed study will provide data and information to “effectively manage ground-water and surface-water resources for domestic, agricultural, commercial, industrial, recreational, and ecological uses” and “protect and enhance water resources for human health, aquatic health, and environmental quality.”

The proposed study effort is consistent with the USGS North Carolina Water Science Center 2003-2008 Science Plan (Bales and others, 2004; <http://nc.water.usgs.gov/reports/ofr041025/> accessed on January 10, 2011) goal of providing “relevant, high-quality, scientific information that permits resource management agencies to improve the scientific basis for aquatic-habitat restoration decisions and to facilitate integration of scientific information relevant to restoration science.”

Benefits of this investigation to project partners and others include:

- Assessment of how well the existing regulations related to permitted swine CAFOs are protective of human health and the environment;
- Information that can be used to drive effective changes to regulations or procedures;
- Baseline data that can be used to scientifically evaluate the potential water-quality improvements resulting from changes in the management of swine CAFOs.

## Approach

This section describes the approach to be used to meet study objectives. The specific tasks to meet the study objectives are as follows:

1. Develop representative network of stream sampling sites that contain permitted swine CAFOs
2. Collect surface-water samples from sites included in the sampling network for laboratory analysis of nutrients and ions.
3. Conduct an analysis and summary of the data collected during the study.

The approach to be used for each of these tasks is described below.

## **Task 1. Develop representative network of stream sampling sites that contain permitted swine CAFOs**

The proposed study will take place in the North Carolina Coastal Plain to examine the potential influence of swine CAFOs on stream concentrations of nutrients and select ions. A comprehensive evaluation of available information on the site operational characteristics of the existing permitted CAFO facilities in the Coastal Plain will be conducted to develop a network of stream sites that is suitable and accessible for water-quality sample collection, and contains swine CAFOs that are representative of those found throughout the Coastal Plain.

An integrated approach will be used for establishing the network of water-quality sampling sites. The strategy will consist of selecting accessible stream sampling points that are upstream and downstream of CAFO sites and identifying public road crossing at streams for collecting surface-water samples that are located downstream of one or more swine CAFOs. GIS analysis will be combined with data compiled on CAFO operational characteristics to identify road crossings located downstream of multiple swine CAFOs, determine the watershed drainage area at each of the road/stream crossings, and summarize the operational characteristics for all the CAFOs aggregated within the individual watersheds. Road/stream crossings in which no swine CAFOs are located in the upstream watershed drainages also will be included in the network of stream sites for collection of water-quality samples. The sampling strategy also will include individual swine CAFOs within select watersheds where paired surface-water samples (consisting of one upstream and one downstream location) next to individual swine farms can be collected for water-quality analyses. Appropriate landowner permissions will be obtained for stream sampling that requires access through private property.

Part of the approach will be to develop subgroups of sites from the sampling network to allow statistical evaluations of selected site operational characteristics on stream nutrient concentrations. Some of the operational characteristics that will be compiled for each CAFO in the sampling network include number of swine animals, PAN balance of the waste-management system, size of waste application fields, presence of subsurface tile drainage, and years of operation. Additional attributes that will be determined in the selected watersheds include percentage of land use type and soil hydrologic drainage classifications.

After available information is compiled, sampling sites having one or more particular site attributes will be segregated into a matrix of potential subgroups for use in data collection and statistical evaluation. For example, the matrix could include 80 watershed sample locations that are categorized into 4 subgroups of 20 sites each, with the subgroups representing farms having less than 1,000 swine, between 1,000 to 5,000 swine, between 5,000 to 10,000, and more than 10,000 swine. Evaluation of data collected from this type of sampling matrix could be used to determine if swine density at sampled watersheds has a statistically significant effect on stream nutrient concentrations. A similar approach can be used to evaluate water-quality data collected at individually sampled swine CAFOs within the watersheds. The subgroups of sample sites could be further refined to reflect differences in other operational characteristics, such as the presence or absence of tile drainage. The sampling network design is intended to allow collection of water-quality data for use in evaluating water-quality conditions among individual swine CAFOs, among watersheds having multiple swine CAFOs, and between watersheds where swine CAFOs are either present or absent.

During the first 6 months of the project, USGS staff will compile necessary information and develop a list of candidate sites, including watershed road/crossing locations and individual swine CAFOs, to be considered for use in the study. Subsequent to developing the list of candidate sampling sites, USGS will collaborate

with NCDENR DWQ staff to review compiled information on watershed characteristics and CAFO site operational attributes, and to finalize the sampling network to be used in the study. This will include determination of the total number of sites, principal variables of interest, and sample subgroup matrix to be used for data collection and analyses. In the event that more sites are identified than needed, a random selection process will be used in selecting the sampling locations included in the study. After USGS and NCDENR DWQ have finalized the network of stream sampling sites targeted for study, the project budget allocated to collection of field data will be finalized to appropriately support data collection activities for the sampling site network. Upon completion of these steps, USGS will initiate sampling at the selected study sites, as described below in Task 2.

## **Task 2. Collect surface-water samples from sites included in the sampling network for laboratory analysis of nutrients and ions**

### **Sample collection strategy**

The sampling strategy must include enough sites to be representative of the permitted CAFOs located in the Coastal Plain and yet not exceed a number that can be sampled several times within the available funding and timeline. An ideal sampling strategy would consist of multiple samples at each site, such as monthly over several years, to encompass water-quality variations related to season or streamflow conditions (such as storm flow versus baseflow). This would be necessary if the goal were to collect data for use in examining temporal trends or computing stream nutrient loads. Such a sampling frequency is not practical for this study based on the large number of sites being targeted for sampling and budgetary constraints. The primary objective of the proposed work is to determine whether there is a measurable influence of swine CAFOs on stream surface-water quality; for instance, are stream nutrient concentrations in watersheds having permitted swine CAFOs influenced by the density of swine animals raised in the watersheds, and are surface-water concentrations of nitrate or chloride higher at sites immediately downstream of swine CAFO waste-application fields relative to sites upstream of the application fields.

Based on project financial and manpower constraints, it is projected that up to 112 individual surface-water sites may be sampled as part of the study; however, the ultimate number of sites included in the sampling network will be finalized as described in Task 1. As previously mentioned, the North Carolina EMC is considering a potential recommendation to implement a proposed rule (15A NCAC 02T .1310-.1311) that would require water-quality monitoring at permitted CAFOs in North Carolina. Specific information on the proposed rule can be accessed at: <http://portal.ncdenr.org/web/wq/aps/afo/news-updates/water-quality-monitoring-petition>. As part of the proposed rule, surface-water samples would be collected at the CAFOs three times per year, including a sample in January or February, a sample following a land-waste application event during March or April, and a sample following a land-waste application event during July through September. A similar sample collection strategy is being considered for this proposed work where three rounds of samples will be collected at each site included in the sampling network. A round of sample collection is proposed during each of the following periods: January-March, May-July, and September-November. The proposed strategy for each round of sample collection is to minimize the amount of time necessary to sample all sites and to the extent possible, minimize potential effects of significant rainfall events that may drastically influence streamflow conditions during sampling.

Because a primary goal of the study is to determine whether differences in constituent concentrations can be observed between watersheds having different densities of swine populations and PAN balances, and

between sites upstream and downstream of individual swine CAFOs, the sampling strategy will attempt to avoid periods of significant precipitation and overland runoff to streams. High runoff can dilute concentrations of dissolved constituents in surface water, and thus obscure potential differences between sampling locations. With a round of sample collection taking approximately 1 month to complete, it is probable that rainfall may occur over some or all of the sample sites in the Coastal Plain during the sampling period.

Available precipitation data (from rain gages operated by the USGS and/or the NC Climate Office) and streamflow data from USGS gages will be analyzed during each sampling round to minimize the collection of samples immediately following heavy rainfall and during very high streamflows. For instance, sample collections at sites influenced by 1 inch of rain during a 24-hour period may be delayed by 2-3 days. Also, data on percentiles of streamflow for gages closest to sample sites will be compiled and used to limit planned sample collections to those times when discharge at the nearby gages is less than the 75<sup>th</sup> percentile of flow, helping to avoid the highest streamflows. As an example, assume the long-term average 75<sup>th</sup> percentile of flow during the month of January is 50 cubic feet per second (cfs) for a streamgage near several targeted sample sites. For a January sample round, the sites would be sampled if the current discharge at the nearby gage was less than 50 cfs at the time of sampling. Conversely, if rainfall occurred and stream discharge at the gage were to rise to 75 cfs, the sampling would be delayed until discharge dropped below 50 cfs.

## Constituents

Water-quality samples will be collected at surface-water sites for laboratory analysis of nutrients and select ions (table 1). Nutrient analyses will include measurement of dissolved nitrite plus nitrate, dissolved ammonia, total ammonia plus organic N, and total phosphorus. Analyses of major ions will include measurement of dissolved chloride, sodium, and potassium. Measurement of these ions will provide additional chemical information for evaluating potential inputs of animal-waste contaminants from swine CAFOs to adjacent streams. Chemical analyses of water samples will be conducted at the USGS National Water Quality Laboratory (NWQL) in Denver, Colorado.

**Table 1.** Constituents to be analyzed in surface-water samples (Diss., dissolved; N, nitrogen; --, not applicable; NWQL, National Water Quality Lab).

Constituent group	Analyte (unit)	Reporting level	Laboratory
<b>Water-quality samples</b>			
Nutrients	Diss. nitrite+nitrate (mg/L as N)	0.04	USGS NWQL
	Diss. ammonia (mg/L as N)	0.02	
	Total ammonia+organic N (mg/L as N)	0.10	
	Total phosphorus (mg/L as P)	0.008	
Major ions	Diss. chloride (mg/L)	0.12	USGS NWQL
	Diss. sodium (mg/L)	0.18	
	Diss. potassium (mg/L)	0.04	
Physical	Specific conductance (µS/cm)	--	USGS field
	Dissolved oxygen (mg/L)	--	
	Water temperature (degrees Celsius)	--	
	pH (pH units)	--	

After USGS and NCDENR DWQ have finalized the network of sample sites during completion of Task 1, the project budget allocated to collection of field data will be evaluated to finalize the number of sites and rounds of sample collection that will be included as part of Task 2.

### **Data collection techniques**

Established, documented protocols will be followed for collecting and processing environmental samples for water-quality analyses (U.S. Geological Survey, variously dated) except as noted in the following discussion. Ordinarily, when surface-water flow conditions permit, sample collections are based on an integrated equal-width interval (EWI) sampling technique, which involves collecting an isokinetic width- and depth-integrated sample, composited in a churn splitter and processed and preserved according to USGS standard operating procedures. When surface-water flow conditions do not permit EWI sampling, nonisokinetic grab samples are collected at equal width intervals and composited.

The following variance to standard EWI sampling is proposed for this study. When surface-water flow conditions permit, isokinetic depth-integrated samples will be collected at 3 locations across the stream, including midstream,  $\frac{1}{2}$  the distance between midstream and left bank, and  $\frac{1}{2}$  the distance between midstream and right bank. When surface-water flow conditions do not permit EWI sampling, nonisokinetic grab samples will be collected only at the midstream location, unless local conditions, such as an inundated flood-plain/swamp system, prohibit access to the middle of the channel which may require collection of samples closer to the stream bank. This variance in sample collection methodology is needed to minimize the amount of time and equipment required for efficiently sampling a large number of surface-water sites during each sampling round. Information on sample-collection locations and methods will be documented at each study site. The field sampling tasks will include the collection and laboratory analysis of replicate samples and field blanks for quality assurance (QA) and quality control (QC) purposes. Both the environmental samples and associated QA/QC samples collected during the study will be shipped to the USGS NWQL in Denver, CO for analysis of nutrients and ions (table 1).

Specific conductance, dissolved oxygen, water temperature, and pH will be measured during sampling at each study site. Field water-quality instruments will be calibrated and operated according to USGS protocols (U.S. Geological Survey, variously dated). When conditions permit, instantaneous measurements of discharge will be conducted during sampling at the watershed road/stream sample locations included in the network of study sites.

### **Task 3. Conduct an analysis and summary of the data collected during the study**

The water-quality analytical results will be used to characterize surface water in streams receiving inputs from permitted swine CAFOs in the North Carolina Coastal Plain. Surface-water concentrations of nutrients (nitrite plus nitrate, ammonia, ammonia plus organic N, and phosphorus) and ions (chloride, sodium, and potassium) will be used in the characterization. Concentrations of individual constituents, as well as ratios of constituents (such as nitrate/chloride and potassium/chloride), will be summarized for both watershed sample locations, and sample locations immediately upstream and downstream of individual swine CAFOs.

Data will be examined using appropriate statistical methods, such as Wilcoxon rank test, analysis of variance (ANOVA), and multiple comparison analyses (Helsel and Hirsch, 1992) to evaluate whether there are significant effects of swine CAFOs on stream water quality. Constituent concentrations at watershed

sites and individual swine CAFO sample sites will be compared statistically to determine if there are similarities or differences between watersheds and between sites located downstream of swine CAFOS relative to upstream sites. Statistical comparisons also will be performed to determine if there are significant correlations between observed differences in constituent concentrations, if any, and associated site operational characteristics (variables) at the swine CAFOS.

If it is assumed that a total of 80 watershed stream sample locations were included as part of the site network, then a potential sample subgroup matrix that could be developed for statistical comparisons is illustrated in table 2. In this example, principal site groups reflect a gradient in watershed swine density, with 20 sites/group. The swine density could be based on the number of animals per CAFO that is normalized to weight of finishing pigs or average PAN balance of the waste management system at each CAFO. Intuitively, one may hypothesize that CAFOs with the highest number of animals or highest amount of generated waste-manure PAN may have the highest potential for effecting adjacent stream water quality. Hence, a principal grouping of sites based on an animal density gradient would be useful to explore potential relationships between stream concentrations of nutrients and ions among sites with different animal densities. The four principal groups could be further divided into four subgroups of 5 sites each to examine additional variables that reflect differences in site operational characteristics at the CAFOs (such as farms with tile drainage, farms without tile drainage, CAFOs < 20-years old, and CAFOs > 20-years old).

Final determination of the site network and sample subgroup matrix will be contingent upon completion of Task 1. USGS will collaborate with NCDENR DWQ staff to review information compiled on the CAFO site attributes and determine the principal variables of interest to include as part of the sampling strategy and data analysis. Results of all water-quality analyses and statistical evaluations conducted during the study will be compiled and summarized for inclusion in the final project report.

**Table 2.** Hypothetical matrix for subgrouping a network of sampling sites for statistical data analysis.

Principal group	Subgroups			
Swine density (# sites)	Variable 1 (# sites)	Variable 2 (# sites)	Variable 3 (# sites)	Variable 4 (# sites)
< 1,000 (20)	5	5	5	5
1,000 - 5,000 (20)	5	5	5	5
5,000 - 10,000 (20)	5	5	5	5
> 10,000 (20)	5	5	5	5

## Quality Assurance

As the Nation's principal earth-science information agency, the U.S. Geological Survey has developed a worldwide reputation for collecting accurate data and producing factual and impartial interpretive reports. To ensure continued confidence in its products, all scientific work is conducted in accordance with documented QA policies and procedures.

The USGS Quality Assurance Plan for Water-Resources Activities in North Carolina (USGS, 2010a and 2010b) provides a framework for defining the precision and accuracy of collected data. The plan is supported by a series of quality-assurance policy statements that describe responsibilities for specific functional elements, including project planning and implementation, equipment calibration and maintenance, data collection, data processing, review and storage, data analysis and interpretation, synthesis, reports preparation and processing, and training. Activities of the Water Science Center are systematically conducted under a hierarchy of supervision and management that is designed to ensure conformance with Agency goals of quality assurance. All methods used by the USGS to collect and review scientific data are fully documented, and project data and records are archived in accordance with guidelines jointly approved by the USGS and the National Archives and Records Administration. Reports produced by the USGS are peer-reviewed and conform to standards established for scientific ethics.

Project water-quality data collection activities will be conducted in accordance with the Quality-Assurance Plan for Water-Quality Activities of the North Carolina Water Science Center (U.S. Geological Survey, 2010a). Equipment cleaning and sample collection and processing will follow procedures outlined in the USGS National Field Manual for the Collection of Water-Quality Data (U. S. Geological Survey, variously dated). Any deviations from established protocols that are necessitated by the proposed study design will be documented in writing, and data integrity will be checked with quality assurance samples.

Results from environmental sampling may be subject to bias (or systematic error) and variability (or random error) during sample collection, processing, and analysis. The nature and magnitude of bias and variability can be determined by analysis of quality-control samples, including laboratory and field blanks, field replicates, and performance-evaluation samples. Based on the total number of environmental surface-water samples collected during the study, an additional 10 percent will be collected as blanks (equipment blanks and field blanks) and replicate samples for quality assurance of sample collection procedures and laboratory analyses. All samples collected by USGS will be analyzed at the USGS NWQL in Denver, Colorado, which is accredited by the National Environmental Laboratory Accreditation Conference. The NWQL adheres to a comprehensive Quality Management System to ensure the quality of its work processes, products, and services (Maloney, 2005). Laboratory blanks, continuing calibration verification checks, and blind performance-evaluation samples routinely are analyzed, and results are available to project personnel.

Project personnel and the NC Water Science Center (NCWSC) Water Quality Specialist will review all field and laboratory analytical results. Requests for re-analysis will be made to the NWQL when results are in question. Data will be entered into the USGS National Water Information System (NWIS) data base. Data stored in NWIS pass through automated quality-control checks of data consistency and will be available online.

## Products

All data collected and analyzed by the USGS will be archived in the USGS National Water Information System (NWIS) database and available via the internet. USGS will publish an online USGS Scientific Investigations Report, documenting the data collection and approach used to characterize the effects of swine CAFOs on water-quality conditions in adjacent streams. The report will be served online via the USGS Publication Warehouse and the USGS North Carolina Water Science Center websites. USGS reports receive extensive technical and editorial reviews prior to approval for publication by the Director of the USGS. An oral presentation on the results of the study will also be provided to NCDENR staff as requested.

## Personnel

A senior-level hydrologist will serve as project chief to manage the project, report to the cooperator, oversee quality assurance, compile and evaluate data, provide data interpretation, make presentations, and write the final report. An assistant project hydrologist will aid with compilation of site attributes, database processing, sample preparations and collections, and data compilation and summaries. IT specialists will assist with GIS mapping of CAFOs and analysis of site operational characteristics. The NCWSC water-quality specialist will provide general guidance and assist with project quality assurance activities. Other NCWSC staff technicians and hydrologists (GS-6 to GS-11) experienced in water-quality sampling will serve on teams to collect surface-water samples at the study site network. Other NCWSC staff hydrologists (GS-11 to GS-13) will assist in data review and compilation, quality assurance, and statistical analysis.

## Project funding, timeline, and deliverables

The proposed project is a three-year study (July 2011 - June 2014) that will span a total of four Federal fiscal years. Anticipated project costs are estimated at \$1,000,000 and will be shared equally by DWQ and USGS, subject to the availability of Federal funds. The project cost sharing arrangement is summarized in table 3. Subsequent to finalizing the study network of sampling sites as part of Task 1, USGS and DWQ will evaluate anticipated project costs and make any necessary modifications to the proposed level of funding, if warranted, to support completion of study Tasks 2 and 3.

A general timeline of project activities is summarized in table 4. Compilation of available site attribute information on the swine CAFOs and development of GIS coverage's will begin in July 2011. Finalization of the study network of sampling sites and sampling strategy is planned to be complete by January 2012. Collection of 3 rounds of surface-water samples at the study sites is planned to begin in January 2012 and conclude by November 2012. Sample results will be made available to DWQ on or before June 2013. Publication of the USGS report is planned to be complete by June 30, 2014.

**Table 3.** Summary of project cost sharing arrangement by Federal fiscal year.

	FY11 (July 11 - Sept 11)	FY12 (Oct 11 - Sept 12)	FY13 (Oct 12 - Sept 13)	FY14 (Oct 13 - Jun 14)	Project total
DWQ (50%)	\$26,000	\$225,000	\$187,000	\$62,000	\$500,000
USGS (50%)	\$26,000	\$225,000	\$187,000	\$62,000	\$500,000
Totals	\$52,000	\$450,000	\$374,000	\$124,000	\$1,000,000

**Table 4.** Proposed project schedule, by quarter [**X**, task activity is planned]

Task	TIMELINE											
	Jul- Sept 2011	Oct- Dec 2011	Jan- Mar 2012	Apr- Jun 2012	Jul- Sept 2012	Oct- Dec 2012	Jan- Mar 2013	Apr- Jun 2013	Jul- Sept 2013	Oct- Dec 2013	Jan- Mar 2014	Apr- Jun 2014
Compile CAFO site attributes and GIS coverages, and establish access permissions	X	X										
Finalize site network, sample strategy, and matrix of statistical sample subgroups		X	X									
Conduct site visits and collect 3 rounds of surface-water samples at site network for lab analyses			X	X	X	X						
Data compilations and quality assurance; statistical processing; prepare report figures and tables							X	X	X			
Prepare draft of a USGS publication and submit for internal reviews									X	X	X	
Publish USGS report online and present results to NCDENR staff											X	X

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