Inventory of Selected Items for Nutrient Loading Reduction

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Background

The Falls Lake Nutrient Management Strategy, developed and enforced by the North Carolina Department of Environment and Natural Resources (DENR), requires that local governments of jurisdictions within the Falls Lake watershed develop programs to reduce nutrient loading in the receiving waterbody. There are two stages to the strategy, the first of which requires each jurisdiction to submit, by January 2013, inventories characterizing the load reduction potential for six primary programs.

This document fulfills the Stage I load reduction inventory requirements under 15A NCAC 02B .0278(3), and describes Granville County's opportunities for load reduction through the six means or techniques described in that section. It is submitted by Granville County for approval by the Commission.

Stage I Load Reduction Programs

Under Stage I of the programs, local governments must develop inventories and characterize load reduction potential (to the extent that accounting methods allow) for each. Granville County's programs and the associated load reduction potential are described below.

Wastewater Collection Systems

Nutrient loading can be reduced through the improvement of wastewater collection systems. Specifically, proper system maintenance will result in a reduction in both dry weather leaks to surface water and wet weather overflows, which will in turn reduce nutrient loading. In Granville County, the South Granville Water and Sewer Authority (SGWASA) has jurisdiction over the wastewater collection system and treatment plant. As such, SGWASA is responsible for the maintenance of the system and is the beneficiary of any nutrient load reductions realized through that program. These load reductions are not expected to apply to Granville County's load reduction program.

Discharging Sand Filter Systems

There are no discharging sand filter systems within the Falls Watershed in Granville County. Therefore, there is no opportunity to achieve load reduction within this program.

Septic Systems

An inventory of septic systems throughout Granville County is included in the *Person and Granville County Septic System Field Performance Assessment*, being completed by NC State. The results of this assessment will be presented under a separate cover from this inventory.

Utility Corridors

Utility corridors are commonly mowed areas surrounding above-ground components of utility infrastructure. Restoration of barren or grassy utility corridors to those supporting hardier vegetation could reduce runoff via interception and consequently reduce nutrient loading. According to the Jordan/Falls Lake Stormwater Nutrient Loading Accounting Tool, the conversion of managed pervious cover (the assumed cover for utility corridors) to forested cover will yield load reductions of .85 lbs/ac/yr of N and .18 lb/ac/yr of P.

Granville County has limited to no opportunities to replace or supplement existing vegetation with species which will reduce runoff in utility corridors. The reason is that in preliminary discussions with the utilities involved, they have expressed strongly that the current corridors are already cleared to the minimum widths that the utility requires. The power utilities sustain heavy fines from the Federal government for any outages that are attributable to vegetation.

Since this reduction would be contingent upon the application of a conservation easement on the land, as well as an agreement from an operational perspective that the utility could provide its services with a narrower easement, it is unlikely that significant reductions can be achieved from re-vegetation.

Fertilizer Management Plan

In many cases, fertilizers containing nutrients such as phosphorus, nitrogen, and potassium are applied to managed vegetation in excess of levels that can be taken up by the grass. Stormwater runoff can quickly transport remaining nutrients to receiving water bodies. For local government-owned properties, this nutrient loading can be reduced with a variety of strategies, addressing fertilizer composition, application, and maintenance.

Granville County only maintains one 11-acre cemetery property in the Falls Watershed where fertilizer is applied. Granville County is investigating options for nutrient reduction, while also assuring that the cemetery is properly landscaped.

Structural Stormwater Practices

There are opportunities for retrofitting of BMPs (per DENR's Stormwater Best Management Practices Manual) throughout the Falls Watershed area of Granville County to reduce nutrient loading. BMPs that are available for retrofitting have primarily been implemented under erosion and sedimentation control programs administered by the State. The following table describes these practices along with roughly estimated acreage draining to each structure and potential associated nutrient loading reduction that might be achieved if the structures were retrofitted. Below are some notes about the estimation method used.

- Acreage Impacted: Because the County does not administer a local erosion control program, the County does not have very detailed information on these structures. Thus, the acreage impacted is an approximation from development information submitted to the County: the total site area for the developments concerned was divided equally among the structures on the site. In other words, each structure within a development was assumed to drain an equal portion of the site. The County is continuing to gather information on these structures.
- Retrofit possibility: Most structures are functioning like dry detention basin, although likely not as extended dry detention basis. Dry detention structures could be retrofitted to be wet detention basins. A few basins are functioning as wet detention ponds and for the purposes of the inventory, it is assumed that these could be retrofitted to be constructed/stormwater wetlands.
- Potential % Improvement in Nutrient Removal: The nutrient loading reductions are stated in terms of improvement in the percent removal of nutrients the structures could achieve. The

assumed percent removal in N and P for dry detention, wet detention, and constructed wetlands are taken from the NC DWQ Stormwater BMP Manual and these percentages are shown in table 2.

The locations of these structures are also displayed on the map in Appendix A.

Table 1 Stormwater BMPs and Nutrient Loading Reduction Potential

Structure Location	Intended Purpose	Area Impacted (Approx Acres*)	Condition	Retrofit Possibility**	Potential % Improvement in Nutrient Removal
Bradsher Dr.	Erosion Control	51	Fair	Dry to wet detention	15% N; 30% P
Saddle Ridge Rd	Erosion Control	28	Fair	Dry to wet detention	15% N; 30% P
1542 Raven Wood Dr.	Erosion Control	17	Fair	Dry to wet detention	15% N; 30% P
3860 Ironwood Dr.	Erosion Control	63	Fair	Wet detention to stormwater wetland	15% N; 0%P
Near End of Ironwood Drive (left Side)	Erosion Control	30	Fair	Wet detention to stormwater wetland	15% N; 0%P
Near End of Ironwood Drive (right Side)	Erosion Control	30	Fair	Wet detention to stormwater wetland	15% N; 0%P
Left Side of Anterra Dr.	Erosion Control	21	Fair	Dry to wet detention	15% N; 30% P
Right Side of Anterra Dr.	Erosion Control	21	Fair	Dry to wet detention	15% N; 30% P
End of Cul-de-sac on Bayview Ct	Erosion Control	18	Fair	Dry to wet detention	15% N; 30% P
Garner Terrace Way	Erosion Control	46	Fair	Dry to wet detention	15% N; 30% P
Right Side of Dovefield LN #1	Erosion Control	33	Fair	Dry to wet detention	15% N; 30% P
Right Side of Dovefield LN #2	Erosion Control	33	Fair	Dry to wet detention	15% N; 30% P
4006 Cashmere LN	Erosion Control	32	Fair	Dry to wet detention	15% N; 30% P

Structure Location	Intended Purpose	Area Impacted (Approx Acres*)	Condition	Retrofit Possibility**	Potential % Improvement in Nutrient Removal
1069Wheeler Pond RD	Erosion Control	58	Fair	Wet detention to constructed wetland	15% N; 0% P
#1 on Hawthorne Lane @ recreation center	Erosion Control	35	Fair	Dry to wet detention	15% N; 30% P
#2 on Hawthorne Lane	Erosion Control	35	Fair	Dry to wet detention	15% N; 30% P
End of Juliette Lane	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
East Bay Ct #1	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
East Bay Ct #2	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
East Bay Ct #3	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
East Bay Ct #4	Erosion Control	8		Dry to wet detention	15% N; 30% P
Between 677 & 679 Willard Dr	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
End of Cul-de-sac on Vesterby Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
3041 Vesterby Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
End of Cul-de-sac on Willard Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
649 Willard Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
656 Willard Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P
Between 657 and 659 Willard Dr.	Erosion Control	8	Fair	Dry to wet detention	15% N; 30% P

*Rough approximation of acres that could be affected

**All retrofit possibilities require further investigation by Granville County as the Stage I program is developed.

Table 2. State BMP Manual Assumed % Removal for N and P for Selected BMPs

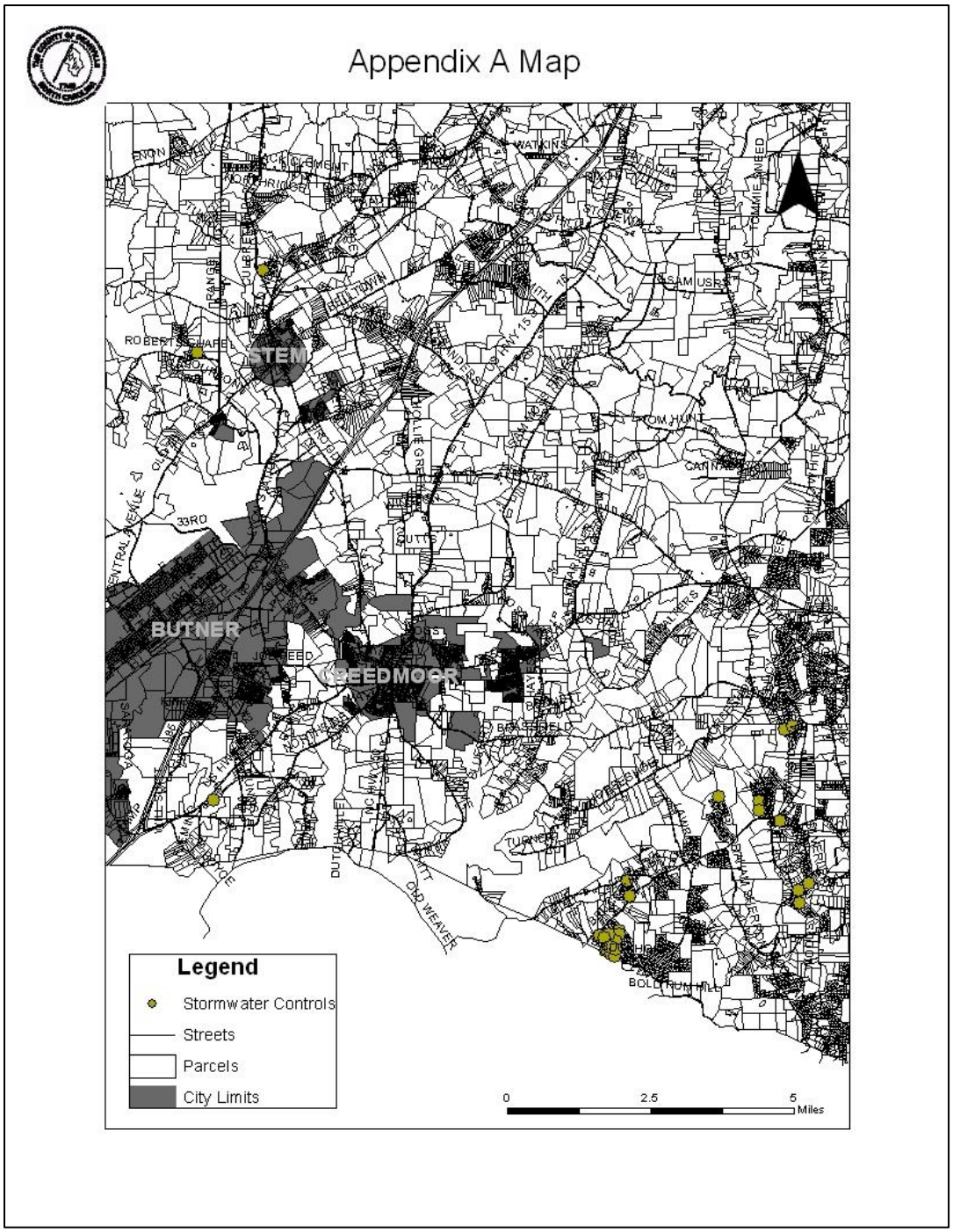
	State BMP Manual Assumed % Removal	
Type of Structure	N	P
Dry Extended Detention	10	10
Wet Detention	25	40
Stormwater Wetland	40	40

Wetlands and Riparian Buffers

Local governments may restore riparian buffers on developed or agricultural lands where riparian zones are currently under cultivation or other managed vegetative cover. Granville County has investigated the potential for riparian area restoration and has not identified any opportunities to date.

Jurisdictional wetlands are displayed the map included as Appendix A. DWQ has not specified accounting methods for nutrient load reduction through wetland restoration. Granville County has not been able to identify any significant opportunities for wetlands restoration in the jurisdiction.

Appendix A. Nutrient Load Reduction Programs Reference Map



Granville County Septic System Field Performance Assessment

Preliminary study report to North Carolina Division of Water Quality

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1. Introduction

1.1 Background

Due to violations of the State chlorophyll-a standard caused by excessive nutrient inputs, the North Carolina Division of Water Quality included Falls Lake on the State's 303(d) list in 2008. As a result the Falls Lake Nutrient Strategy was developed to reduce nutrient loadings, specifically nitrogen and phosphorus into Falls Lake. The Falls Lake nutrient strategy rules were approved by the NC Rules Review Commission on December 16, 2010 and went into effect on January 15, 2011.

The Falls Lake Nutrient Management Strategy, in preparation for implementation of their Stage I and Stage II load reduction program, calls for all counties in the Upper Neuse River Basin to determine the extent of failing (malfunctioning) septic systems within their portions of the Falls Lake watershed. This Granville County septic system field performance survey was conducted as partial fulfillment of the County's requirement to perform an inventory of properly functioning and malfunctioning septic systems under 15A NCAC 02B .0278 for the Falls Lake Nutrient Strategy.

In the United States, 25% of the total housing units and 33% of all new development rely upon decentralized wastewater treatment systems (also called septic systems or on-site systems) for their household wastewater treatment (USEPA, 2005 U.S). Some states, such as North Carolina where 50% of the population depend upon on-site systems, utilize these technologies even more extensively (Pradhan, et. al, 2007). On-site systems disperse wastewater into the soil where physical, chemical and biological treatment processes remove pathogens and many of the potential chemical pollutants in sewage effluent. The number of on-site wastewater treatment system users increases every year as a result of continuous urban and suburban sprawl, rural development and the high cost of central sewer systems.

Decentralized wastewater treatment systems can be environmentally friendly, safe to human health and permanent wastewater treatment solutions, if closer attention is provided to use, inspection, operation and management of the systems. If septic systems are not properly maintained, they will not function properly, which is called malfunctioning or surface discharge failing systems. Failure of on-site wastewater technologies can manifest itself in a number of ways. Failure can occur as a discharge of sewage effluent on the ground surface, a "straight pipe" discharge of untreated sewage effluent (including greywater) to a ditch, stream or swamp, as a backup of sewage into the home or facility or as inadequate treatment of the wastewater prior to entering the ground water system underlying the drainfield ((Pradhan, et. al, 2007). No national rules exist for on-site technologies, hence each state, county or local jurisdiction may have its own rules. As a result, specific definitions for failure vary among jurisdictions. The failing system has potential to cause negative effects to public health as well as to environment. Failing systems in any location are of concern because of the potential for disease transmission and nutrient and bacteria loading in surface waters (streams, rivers and lakes). Note that Granville County is directly

adjacent to portions of the Falls Lake watershed and directly runoff into the Lake. Malfunctioning septic systems can have direct impacts on Lake water quality.

Drs. Suhama Prandhan and Mike Hoover from Department of Soil Science at NCSU and from the Granville County Cooperative Extension Center provided assistance to the Local Health Department in designing and implementing a scientifically sound and pragmatically useful failure rate assessment study in the Falls Lake watershed area within southern Granville County. Paul Westfall of Granville County Cooperative Extension Center and Wallace Vaughan of Granville-Vance District Health Department (DHD), Casey Champion of Granville-Vance DHD, Derek Day of the Person County Cooperative Extension Center, worked in a leadership capacity along with Dr. Sushama Pradhan and Craig Callis within Dr. Mike Hoover's wastewater technology enhancement program in the Soil Science Department at NC State University.

1.2 Study Purpose

The overarching goal of survey was to conduct a science-based septic system field performance study that correctly determines representative surface failure rates for septic systems installed within the Falls Lake watershed portions Granville County**.**

2. Study Design

2.1 Overview

Properly designed and well thought out research-based studies are necessary if the on-site wastewater regulatory decision-making process is to be science-based (Groves, et al., 2005; Hoover and Beardsley, 2001; Hoover and Beardsley, 2000). A field performance survey methodology that was first used by Hoover (1979) and Hoover et.al. (1981) was modified for recent failure rate studies in Wake County, North Carolina, (Lynn et al., 2005) was used for this survey. The survey consisted of both a visual inspection and questions to the property owner. The homes or businesses involved in the survey were randomly selected from the Falls Lake watershed area within Granville County. The population from which the sample was taken consisted of all residential and commercial septic systems built in the watershed portion. A field performance survey was conducted to identify the **surface discharge failing (malfunctioning) rates** of on-site systems in the portions of the Granville County that belong to the Falls Lake watershed.

Note that the terms "failure" and "malfunction" are used interchangeably in this report. Therefore, "failure" as used here does not mean that a particular septic system has reached the end of its useful lifespan for the system owner. The systems identified in this study that are in a state of malfunction can frequently be remediated to become functional again.

2.2 Research Protocol

A generic research protocol for scientifically valid surveys, called "42-steps process for failure rate studies", developed by Dr. Hoover was used in this study. The protocol is appended in Appendix –A. The 42-step failure rate survey process involves specific methods for planning, designing, defining the study population, selecting an appropriate random sample of septic systems from that population to be studied, including the field work and reporting survey findings. This failure rate study process allows for nearly instantaneous assessment (taking 2-4 days) of failure rates from a sample of 150 to 300 septic systems, all evaluated under similar soil moisture conditions. Thus, using this process, an entire area of interest can usually be quickly and efficiently surveyed providing highly valued and representative datasets.

Each step in the 42-step process represents a specific project element or task that is required to properly achieve the project goal at the highest level. These steps are necessary to produce a scientifically defensible study providing a meaningful failure rate that can be scientifically extrapolated to the entire population of septic systems in the study area (for instance a county). Forty two tasks are organized into four project phases as presented in Table 1. Leadership roles (NCSU, County Health Department and County Cooperative Extension) are indicated for each element.

Table 2-1. Project phases, tasks (elements) and responsible organizations in the failure rate study.

Phases	Tasks	Primary Organization
Phase 1: Planning and study design (Steps 1 – 15)	1. Define the problem	1. CHD, CCE and NCSU
	2. Evaluate the decisions that will need to be made after the study is completed	2. NCSU and CHD
	3. Determine the questions to be answered	3. CHD and NCSU
	4. Develop the hypothesis (and null hypothesis) to be tested	4. NCSU
	5. Determine the factors to be assessed	5. CHD, CCE and NCSU
	6. Develop a written protocol with proper statistical tests and sample size for detecting important differences	6. NCSU
	7. Have the protocol peer-reviewed	7. NCSU
	8. Study leadership via third party scientists to maintain independence from funding agency (whether it is a manufacturer or a regulatory body)	8. NCSU
	9. Identify critical attributes of an appropriate study area (locality)	9. CHD, CCE and NCSU
	10. Determine the stratification factors to be tested or to be controlled by blocking	10. NCSU and CHD
	11. Define the study population from permit data or other datasets (determine if there are permit data summary logs or files)	11. CHD, CCE & NCSU
	12. Minimize bias during selection of the population to be studied	12. NCSU
	13. Assign every system in the population a numerically sequential number	13. NCSU
	14. Generate sets of random numbers and use to randomly select the study sample for each stratum in	14. NCSU

	the population 15. Over-select the sample size to allow for unusable sites including systems with incomplete or no permit records as well as for non-viable sites	15. NCSU
Phase 2: Preparation for Field Performance Assessment (Steps 16 – 27)	16. Collect permit data and records 17. Assign each sample site a unique identifier number for quality control during data collection and analysis 18. Define "failure" for the study in very specific terms to minimize bias during data collection and analysis 19. Plan to evaluate the system of interest (the treatment) under the same weather conditions as the experimental control (the standard for comparison) 20. Plan to conduct the field performance assessment over no more than 3-10 days (3-5 preferred) to minimize data noise from fluctuating weather conditions 21. For efficiency during the field performance assessment survey itself, reconnaissance of the sites can be conducted prior to the survey to identify their locations and viability (do not contact homeowners during this stage) 22. Use GIS/GPS, tax parcel ID, 911 addres 23. Develop a field survey evaluation instrument to serve as a site specific data collection and compilation guide 24. Transfer permit data to the survey instrument 25. Prepare information packets to give to residents during the survey 26. Divide the study area into survey districts to equally distribute the workload between survey teams 27. Organize files into survey district packets for each team and include GPS locators, GIS locator maps, reconnaissance data and/or detailed field maps for each survey district packet along with field data collection methods and interview instructions	16. CHD and NCSU 17. NCSU 18. CCE and NCSU 19. NCSU 20. NCSU 21. NCSU, CHD & CCE 22. CHD 23. NCSU, CHD & CCE 24. NCSU and CHD 25. NCSU 26. NCSU 27. NCSU and CHD
Phase 3: Study Execution and Data Collection (Steps 28 – 39)	28. Utilize teams for QA/QC during the field performance assessment 29. Train teams together for QA/QC 30. Use mock practicum site(s) for QA/QC 31. Disperse teams and begin data collection 32. Use a one-pass approach for evaluation 33. Use single-blind survey for QA/QC 34. Construct teams to include multi-agency representation for QA/QC 35. Make joint decisions as a team 36. Type of data collected can include system type, water supply, installation date, system location, system inspection data, as-built data, soils data from field assessment, soils data from permit files, number of bedrooms, number of occupants, system history, ponding levels, system performance, failure (Y/N), etc.	28. NCSU 29. NCSU 30. NCSU, CHD & CCE 31. NCSU, CHD & CCE 32. NCSU, CHD & CCE 33. NCSU (optional) 34. NCSU, CHD & CCE 35. NCSU, CHD & CCE 36. NCSU and CHD

	37. Data collected includes site performance data, permit data and questionnaire/interview data 38. Use a quality control team to re-assess performance of approximately 10-20% of systems 39. For failing systems observed during the survey, use the FACTSS and Pump-FACTSS process to determine the causes of failures and assess the extent to which the observed hydraulic performance is due to siting, design, inherent technology factors, installation and/or operation, use and maintenance	37. NCSU and CHD 38. NCSU, CHD & CCE 39. Not included in not included in project. CHD to conduct following field survey.
Phase 4: Data Analysis and Report Preparation (Steps 40 – 42)	40. Assess system performance relative to system type, stratification or blocking factors, climate, soil conditions, landscape position and topography, design, permitting process, installation, operation and maintenance, etc. 41. Have final report peer-reviewed 42. Publish the results, preferably in a journal, if at all possible	40. NCSU and CHD 41. NCSU 42.* NCSU and CHD

- **Note step 42 is only intended to be "started" with this project –the final project report developed in this project will become a stepping stone to later (following project completion) publication of the research results in a peer-reviewed journal.**

Four important steps of on-site wastewater treatment surface discharge failure study are:

- **Phase 1:** Planning and study design
- **Phase 2:** Preparation for Field Performance Assessment
- **Phase 3:** Study Execution and Data Collection
- **Phase 4:** Data Analysis and Report Preparation

These phases are described in following sections.

2.3 Sample Size

If a project goal is to make inferences about a population from sample, sample size is a vital part of study. It is critically important to have an appropriate number of samples in the study to have representative and meaningful survey results. In determining the appropriate sample size, the parameters to be considered are the "confidence level" and "confidence interval" as well as population variance. For this study $1/\sqrt{N}$ approach (Niles, 2006) was used, where *N* is the number of sample size that is needed for a 95% confidence level (which means that there is only a 5% chance that survey results differ from the true population average) at a 90% confidence interval (a good estimate of the margin of error).

Based upon the sample size formula, the number of samples that were needed to be obtained were 100 systems. It is common practice to add 10% to the sample size to compensate for non-viable members of the sample. However we decided to added 20% and thus 120 samples were randomly selected from study population.

2.4 Sample Selection

In order to obtain representative samples from all over the study area, random numbers for the total population of 3,663 parcels using on-site system for wastewater treatment were generated using "RAND" function in Microsoft Excel. A total of 120 samples (20% more than calculated by formula) were randomly selected considering the fact that some people might be unwilling to participate in the study, some systems might already be hooked on to the city sewer and not updated to County EHD database, and the fact that some systems might not be found. Once the desired sample was selected, property “record number” was used as a unique identifier number for tracking system data throughout the remainder of the study. Record number is a unique number assigned to each property by the County Tax Office.

A package with a letter of intent and a homeowner interview questionnaire was mailed to property owners of all randomly selected parcels by the Granville-Vance DHD. The letters were mailed on October 11, 2012 three weeks prior to the intended survey date, so homeowners would have enough time to send the questionnaire back to the Granville-Vance DHD. Two homeowners (1.6%) refused to take part in the survey. A number of the sites (10) were found to be served by centralized sewer systems. Some of the sites with sewer systems were identified during preliminary data gathering and some of sites were notified by homeowners after receiving the letter of intent. Hence 105 systems became the field survey sample. So the sample size of 105 sites accounts 2.9% of the total septic system population of the study area. On the days of the survey one additional homeowner refused to participate, four houses were found to be abandoned, and surveyors could not go to one house due to “no trespassing” sing on the property and two houses were identified with city sewer. So a total of 97 viable sites were included in the study sample.

Four important numbers regarding the design for this study are:

1. Study population (septic systems) in Falls Lake watershed area within Granville County – 3,663
2. Selected sample – 120 systems
3. Field sample – 105 systems
4. Viable study sample – 97 systems

2.5 Reduction of Potential Bias

In order to reduce potential bias at all stages of the study, following steps were used:

1. The study population was designed to include all on-site systems in the watershed regardless of system age (up to 2012), facility served (home, business, commercial type of residence), type of on-site technology used etc.

2. Study samples (120) were randomly selected using the "RAND" function in Microsoft Excel from a spreadsheet compiling all on-site systems in the study population/database.

3. The study population database was obtained from county property records overlain with a GIS map and watershed boundary.

4. The database (study population) included 3,663 septic systems installed within the Falls Lake watershed portions of Granville County.

5. The entire field sample (e.g. 97 viable study sites) was studied within a two day timeframe to minimize bias that could occur resulting from weather condition effects on performance.

6. There was a person from County the Environmental Health Department (EHD) and one non-staff person on each survey teams, so as to minimize any potential personal or professional bias. Agreement had to be reached by all team members that a failure existed before it was recorded as such. Also, a consistency training session was conducted to help normalize interpretation of field condition observation in the survey.

2.6 Characterization of the Study Population

Since the primary objective of the study was to identify malfunctioning (surface discharging) septic systems, samples were randomly selected from entire population without any stratification.

2.7 Data Collection Protocols and Survey Instruments

Various septic systems related data were collected by using a Field Evaluation Survey Instrument and a Questionnaire/Home Owner Interview Survey Instrument. Survey Instrument forms and the letter of intent are presented in Appendix B. Table 2-3 lists all of the information collected during the homeowner interview process. Table 2-3 includes all of the data collection elements from the Field Evaluation Survey Instrument.

Table 2-3: Parameters on the Homeowner Interview Survey Instrument

System age	Septic system repaired
Length of stay in the house	Septic system pumped
Occupancy	Water use modification
Problem ever with septic system - Surfacing in the yard - Backing up into the house Problem appears to be related to - Rainfall - Guests - Laundry - Season of the year	Discharge of harsh chemicals and grease/oil down drain
	Usefulness of how to who to maintain septic system information
	Any dogs at the property

Table 2-2: Parameters on the Field Evaluation Survey Instrument.

Compare aerial photography with current field condition	Vegetation type Grassed – condition: good, fair, poor Wooded On-site surface water diversion from systems
Design flow (gal/day)	
Number of bedrooms	
System type (.1961 Va) Drainfield material product (IIIg) Conventional vs. pump	Additional uses over the system Driveway ___ Pavement ___ Structure___ Patio ___ Landscaping ___ Other ___
Repair permit issued	
Water supply	
System evident from field observation	
Sewage present on soil surface or comes to surface with foot print test	Evidence of system repair
Past/potential indication of possible Failure -- Evidence of recent failure - Bulls-eye vegetative pattern - Bare soil surface with algae - High grass/veg. over tank/lines - Green plume down slope of line - Soft mushy soil over tank/lines	Septic system location - Back yard- - Front yard - Side yard

3. Preparation for Field Assessment

3.1 Data Organization

A file folder was prepared for each site and labeled with the parcel "Record Number". Each file folder was assembled to include the permit, repair permit if present, color aerial photograph, black and white aerial photograph overlain with contour map of the site, the land record information from the County Tax Office and the Field Survey Data Instrument. The orthophotographs were obtained from the Granville County GIS System Office. The System Permit Information section was filled by Granville County Health Department staff as the folder was assembled in order to save time during the field survey. In addition, aerial photography which showed the property and nearby lots, house shape and sizes, driveway locations and other land features were also observed prior to see whether or not visible of system malfunctioning was present. If a suspected area was present, it was circled so when the survey team went to field they pay close attention to the marked area.

3.2 Survey Timing

The septic system filed performance evaluation was conducted in October 29th and 30th of 2012. The survey was planned for 2 days only, so that all assessments would be

conducted under similar weather condition and similar ambient soil moisture status. October 31st was set aside as a backup day in case of inclement weather.

3.3 Survey Areas

The overall survey area was geographically divided into five survey districts, so the survey could be performed in two days. The areas were divided based upon the proximity and number of study sites in each district. Since on-site system failure is related to weather conditions, this approach minimized "noise" in the dataset due to weather condition changes. It also minimized travel time and facilitated easy location of study sites.

Each survey district contained 20 to 23 (Table 3-1) study sites. Survey folders that belonged to each study area were put in separate large survey packets (one pocket for each survey district) to be carried by field survey teams on the day of survey. A total of 105 survey files were grouped and organized into 5 survey packets by the Granville-Vance DHD staff (Cassandra Champion, and Craig Callis (Soil Science Department, NCSU).

3.4 Survey Packets

Each survey packet contained a copy of the Granville County GIS road map showing the survey site locations (by record number), lists of survey site with physical address, field survey instrument and educational materials for septic systems owners. Each survey team was also provided a book of detailed road maps to facilitate site location.

3.5 Survey Teams

Close attention, forming survey team, was paid to reduce bias that could be caused by personal or professional preference. Each team consisted of a team leader who was an employee of Health Dept., not necessarily from Granville-Vance DHD, and a technical assistant or local expert from various agencies (Table 3-1). This purposeful action minimizes the potential of any one individual or organization interjecting bias into the study results (Hoover, 2005).

Having a Granville-Vance DHD and Granville County Cooperative Extension Center staff member on each team helped since they were familiar with the county road system, on-site technology, etc. Some non-EHD members of the team also had on-site technology expertise. They helped with navigation from site to site and provided a fully active team member with no potential program bias or potential direct interest in whether failure rates were high or low. Decisions were made as a team.

Table 3-1: Survey Districts and Team Members

Survey District No.	Team Leader /Affiliation	Team Member//Affiliation
1	Wallace Vaughan Granville-Vance District of Health Dept.	Adam Sarver Person Co. Env. Health Dept.
2	Casey Champion Granville-Vance District of Health Dept.	Craig Callis Soil Science Dept., NCSU
3	David Cumbee Granville-Vance District of Health Dept.	Sushama Pradhan Soil Science Dept., NCSU
4	Harold Kelly Person County Env. Health Dept.	Suzanne Knott Granville-Vance DHD
5	Mac Shingleton Granville-Vance District of Health Dept.	Paul Westfall NC Cooperative Ext. Service

3.6 Consistency Training

To ensure effective incorporation of the survey data into the field survey instrument, there must be consistency with the standards and guidelines provided to surveyors. The information package including field survey instrument, homeowner interview/survey instrument and purpose of the study was emailed to all surveyors so everybody be on same paste. The effectiveness of the survey depends in large part on the consistency in data collection method used and reliability of information gathered. The consistency training session was provided by Dr. Hoover, Soil Science Department, NCSU, in the morning of the first survey day. The consistency training included a detailed review of the survey instruments. A number of interpretive questions were also addressed in this process, along with discussion of legal and other issues related to accessing sites during the field survey. This assured that all teams collected information using the same systematic process.

3.7 Failure Definition and Classification

For the purpose of the study, surface failure of an on-site septic system was defined very specifically as either:

1. sewage being observed on the soil surface during the day of the survey, or
2. sewage surfacing with pressure from the surveyor's foot or
3. presence of a straight pipe.

No probing was utilized to ascertain potential ponding of effluent below the soil surface at the time of the field survey, even though the definition of failure in North Carolina rules does refer to the extent of effluent ponding in the treanch. Also, the

teams did not actuate effluent pumps when they were present. Soil augering was also excluded.

3.8 Notification Prior to Study

Three weeks prior to the study execution, a copy letter of intent and a homeowner questionnaire were mailed to each homeowner (Appendix B). The Granville County Board of Commissioners was presented a memorandum addressing the purpose, time, and mode of execution of the survey. This information also was supplied to the public through a press release and radio announcement. To enhance the safety of the survey teams as well as to minimize any potential concerns in the community, the County Sheriff's office was also notified of the survey.

The letter of intent included what this study is all about, how their property was chosen and when survey team will be in their property. The letter of intent did not include a question regarding whether the survey could be performed on the property because of the potential bias this could introduce into the study sample (Hoover and Hinson, 2001). The concern was that a "prior permission form" would bias the sample due to a "no" responses or lack of response by homeowners with failing septic systems. On the other hand, it was important that the property occupants were aware in advance of the impending survey visits and had the opportunity to decline if it was critical to them.

More than two thirds of homeowners returned questionnaire prior to study. Only two of them declined to participate. Thirteen homeowners contacted the county and informed staff that they were on central sewer systems.

4. Study Execution Data Collection

On the days of survey, October 29 and 30, 2012, the survey teams assembled at a conference room at the Granville-Vance District Health Department, Oxford, NC. The teams met at this common area on each morning of the survey period prior to going into the field. These meetings proved extremely useful in exchange of information/experiences and provided additional opportunity for addressing any interpretive issues. Team members were also instructed to locate any observed system failure or potential past failure on the orthophotograph provided for each of the survey sample sites.

Following steps involved in filed data collection protocol (Appendix B):

1. On arrival at the site, the Granville-Vance DHD team member knocked on the door. If someone was home, the team member presented identification, explained the purpose and mode of conduct of the survey.
2. If homeowner had not returned questionnaire form, then conducted the homeowner interview and completed the Homeowner Interview Survey Instrument.
3. Provide educational materials to the homeowner, if they wish to have one.

4. If no one was at home, leave educational materials at the door and proceed with conducting the field performance assessment and completion of the Field Data Survey Instrument.
5. Discussed each observation and came to agreement regarding every observation recorded on the survey instrument. This consensus agreement was a critical quality control aspect of the study.

The survey teams were able to complete 97 of 105 sites. Then sites were deemed non-viable due to restricted access (1), homeowner refusal (1), city sewer (2) and abandoned houses (4). Homeowner refusal was rare. Homeowner interviews were completed for about 71% of the 97 viable study sites.

Additionally, 17 sites were randomly selected from 105 field samples for a second "blind survey" for quality assurance and control. Normally 5% of total study sample is used for this purpose. In this study we used 17% of total sample for QA/QC purpose. The data from these separate assessments were then compared to establish consistency in observations. These sites were surveyed by quality assurance team on the same day. The quality assurance team comprised of Dr. Mike Hoover, Jimmy Clayton, Carl Cantaluppi, Paul Westfall, Mac Shingleton, Casey Champion and Craig Callis.

5. Data Analysis and Results

Summary of all information collected during field survey and interview with homeowners are presented in Appendix C.

5.1 Quality Control/Quality Assessment Data

Prior to data analysis, quality assurance and control (QA/QC) data were compared with the field data to ensure the integrity and compliance of field survey procedure used during on-site system failure rate study. In order to reduce personal and professional bias, different surveyors were used to gather QA/QC information. Personnel responsible for QA/QC field survey were Carl Cantaluppi (NC Cooperative Extension Service), Paul Westfall (NC Cooperative Extension Service), Mac Shingleton (Granville-Vance DHD), Jimmy Calyton (Person County), Cassandra Champion, (Granville-Vance DHD) and Craig Callis (Soil Science Department, NCSU). Total of 17 (four sites in area 1, three sites each in area 2 and 3, four in area 4 and three sites in area 5) parcels were randomly choose as QA/QC samples. Generally 5% of total sample was chosen as QA/QC sample. The QA/QC sample used here is little over 15% of the survey sample.

Field survey data collected by QA/QC team and field survey teams are presented in Table 5-1. Blank spaces in the table indicate missing information for that parameter. For one parcel (Record No -18568), QA/QC information was not available. When QA/QC team reached to the study site, homeowner refused to participate in survey because, they have already responded to field survey team who reached there before QA/QC team. Parcel 3710 was an abandoned home, so no information was available for this study site. The QA/QC team was in property (Record no 3319) before survey

team and found system was failing. When survey team reached to the property homeowner denied access to the property.

The QA/QC surface failing information (effluent surfacing and straight pipe direct discharges), complied with field survey result 100% of the time. Same was true for indication of malfunction of the system in aerial photography and prediction of potential past failure criteria. Out of 17 samples, one QA/QC sample (6%) did not comply with survey result in predicting potential past failure. QA/QC result did not match with survey results for four sites (23%) in case of whether or not system can be identified/seen without help of permit and whether or not surface water is diverted away from system location. There was only one discrepancy (6%) and two discrepancies (12%) in encroachment and repair evidence parameters surveyed respectively.

Table 5-1. Survey data collected by QA/QC teams and field survey teams.

Survey Area	Recd No.	*Indication of Malfunction	System Inspection				Site Inspection				
			System Evident	Effluent Surfacing	St. Pipe	**Past failure	Grass	Wood	SWD	Encroachment	Repair Evidence
1	25938	No	Yes	No	No	No	Fair		No	None	No
QA/QC	*25938*	*No*	*Yes*	*No*	*No*	*No*	Fair		No	None	No
1	26337	No	**No**	No	No	No	Fair		No	None	No
QA/QC	*26337*	*No*	***Yes***	*No*	*No*	*No*				None	No
1	30461	No	Yes	No	No	No	Good		**No**	**Horse pasture**	No
QA/QC	*30461*	*No*	*Yes*	*No*	*No*	*No*	Good		**Yes**	**None**	No
1	31663	No	Yes	No	No	No	Good		No	None	No
QA/QC	*31663*	*No*	*Yes*	*No*	*No*	*No*	Good		No	None	
2	18568	No	No	No	No	No	Yes		No	structure	No
QA/QC	*18568*										
2	24409	No	Yes	No	No	No	Good		No	None	No
QA/QC	*24409*	*No*	*Yes*	*No*	*No*	*No*	Good		No	None	No
2	28794	No	**Yes**	No	No	No	Good		No	None	**Yes**
QA/QC	*28794*	*No*	***No***	*No*	*No*	*No*	Good		No	None	**No**
3	3710	No									
QA/QC	*3710*	*No*									
3	10994	No	Yes	No	No	No	Good		**Yes**	None	No
QA/QC	*10994*	*No*	*Yes*	*No*	*No*	*No*	Good		**No**	None	No
3	20389	No	Yes	No	No	No	Good		**Yes**	**Structure**	No
QA/QC	*20389*	*No*	*Yes*	*No*	*No*	*No*	Good		**No**	**None**	No
4	15997	No	Yes	No	No	No	Good		**Yes**	None	No
QA/QC	*15997*	*No*	*Yes*	*No*	*No*	*No*	Good		**No**	None	No
4	18254	No	**No**	No	No	No	**Fair**		Yes	None	No
QA/QC	*18254*	*No*	***Yes***	*No*	*No*	*No*	**Good**		Yes	None	No
4	20330	No	**No**	No	No	No	Good		Yes	None	No
QA/QC	*20330*	*No*	***Yes***	*No*	*No*	*No*			Yes	None	No
4	21171	No	Yes	No	No	No	Good		No	None	No
QA/QC	*21171*	*No*	*Yes*	*No*	*No*	*No*	Good			None	No
5	3319	No									
QA/QC	*3319*	*No*	*Yes*	*Yes*	*No*	*Yes*	Good	No	No	None	No
5	20647	No	Yes	No	No	No	Good		Yes	None	No
QA/QC	*20647*	*No*	*Yes*	*No*	*No*	*No*	Fair	No	Yes	None	No
5	22019	No	Yes	No	No	No	Good		No		No
QA/QC	*22019*	*No*	*Yes*	*No*	*No*	*No*	Yes		Yes	None	

Note: * = Indication of malfunction in aerial photography; ** = Potential past failure and SWD = Surface Water Diversion

Over all QA/QC results complied with survey result 95% of the time, which indicates consistency in filed survey and data collection. In summary the survey team consistently collected field data and there was consistent field interpretation (across team) in the survey. The survey results collected from each survey team are consistent and useful for failure rate analysis.

5.2 Failure Rates

Out of 97 viable study sites, a total of 6 sites were found to be surface discharge failing on the day of survey resulting, an overall failure rate of 6.2% (Table 5-2). These included 4 sites with sewage present on the ground surface over the system, 1 site with a straight pipe direct discharge and 1 site with both (sewage on the ground surface over the system and a straight pipe). So, the survey indicated an overall surface hydraulic failure rate of 6.2% for the portion of the Granville County that belongs to the Falls Lake watershed.

There were three non-viable study sites of concern. Two were sites where homeowners declined upfront to participate prior to the survey at the time that homeowner were notified of the study and one represents a homeowner who would not grant access to the study team on the day of survey. In other studies we have found that prior approval requests results in declines from a higher proportion of homeowner who have failing systems compared to those with functioning septic systems. However, in this case there was a low rate of declines (2 declined in advance and 1 declined on the survey day. Hence, we are comfortable that this 6.2% surface failure rate results from the viable sites are meaningful and fully representative of the failure rate in the 3,663 study population.

Table 5-2: Granville County on-site system surace failure rate.

Survey area	Survey team	Number of sites/surface discharge failure types					Failure rate (%)
		Not failed	Septic	St. pipe	Both	Total	
1	Wallace Vaughan / Adam Sarver	22	0	0	0	22	0.0
2	Casey Champion / Craig Callis	16	1	0	1	18	11.1
3	David Cumbee / Sushama Pradhan	13	2	0	0	15	13.3
4	Harold Kelly / Suzanne Knott	21	0	0	0	21	0.0
5	Mac Shingleton / Paul Westfall	19	1	1	0	21	9.5
Total		**91**	**4**	**1**	**1**	**97**	**6.2**
%		**93.8**	**4.1**	**1.0**	**1.0**		

This 6.2% failure rate can be extrapolated to the entire study population of 3,663 systems due to the care used at the study design stage (95% confidence level and 90% confidence interval). Hence, it is expected that about 227 septic systems were in surface hydraulic failure during the autumn of 2012 within the Falls Lake portion of Granville County.

The failure rate obtained here is smaller than North Carolina State failure rate of 15-20% (EPA, 2002) and Wake county failure rate of 9.7% (Lynn, et. al., 2005). Table 5-3 shows failure rates for different states of the U.S. This table is adapted from on-site treatment system manual from EPA (2002). Failure rate presented here are estimated and vary with the definition of failure.

Table 5-3: Estimated on-site system failure rates.

State	Estimated system failure rate (%)	Failure definition
Alabama	20	Not given
Arizona	0.5	Surfacing, backup, surface or ground water contamination
California	4-Jan	Surfacing, backup, surface or ground water contamination
Florida	2-Jan	Surfacing, backup, surface or ground water contamination
Georgia	1.7	Public hazard
Hawaii	15-35	Improper construction, overflow
Idaho	20	Backup, surface or groundwater contamination
Kansas	15-Oct	Surfacing, nuisance conditions (for installations after 1980)
Louisiana	50	Not given
Maryland	1	Surfacing, surface or ground water contamination
Massachusetts	25	Public health
Minnesota	50-70	Cesspool, surfacing, inadequate soil layer, leaking
Missouri	30-50	Backup, surface or groundwater contamination
Nebraska	40	Nonconforming system, water quality
New Hampshire	<5	Surfacing, backup
New Mexico	20	Surfacing
New York	4	Backup, surface or groundwater contamination
North Carolina	15-20	Not given
North Dakota	28	Backup, surfacing
Ohio	25-30	Backup, surfacing
Oklahoma	10-May	Backup, surfacing, discharge off property
Rhode Island	25	Not given
South Carolina	7-Jun	Backup, surface or groundwater contamination
Texas	0-15	Surfacing, surface or ground water contamination
Utah	0.5	Surfacing, backup, exceed discharge standards
Washington	33	Public health hazard
West Virginia	60	Backup, surface or groundwater contamination
Wyoming	0.4	Backup, surface or groundwater contamination

5.3 System Design

Out of 97 viable study sites, 59 sites were served by conventional septic systems and 32 sites had innovative, pump, non-tradition trench media or other system types. The waste water treatment technologies used by remaining six sites were unknown due to lack of system installation permits. Since the study was not specifically designed to test the impacts of design upon performance, the study population (and study sample selected) was not stratified by system type. However, due to the presence of multiple data points for selected system types, we were able to set relationsh between failing systems and type of systems (Table 5-4).

Table 5-4: System type and failure rate.

System type	Number of sites			Failure rate (%)
	Not failed	Failed	Total	
Type II (Gravity system) 1. Type IIa (Gravel/Conventional)	55	4	59	6.8
Type III (Innovative systems) 1. Type IIIb (Gravel/Pump) 2. Type IIIg (Chamber/Conventional) 3. Type IIIg (EZ-Flow/Conventional) 4. Type IIIgb (EZ-Flow/Pump)	 2 3 19 8	 0 0 0 0	 2 3 19 8	 0 0 0 0
Unknown (Permit not available)	4	2	6	33.3
Overall **Total** %	 **91** 93.8%	 **6** 6.2%	 **97**	

Conventional gravity, gravel aggregate (Type II systems):
All Type II systems surveyed were type IIa conventional septic systems. These systems consist of a septic tank and drainfileds. In Type II gravity system, wastewater from the kitchen, bathrooms, showers and laundry flows into septic tank where it received primary treatment. This partially treated effluent flows by gravity to gravel aggregate trenches for effluent distribution. These 59 systems accounted for 61% of the systems installed over the 51 year period (for which data on system type were available).

Innovative systems (Type III systems)*:*
Type III systems utilize pumps to pump effluent to the trenches or employ other non-conventional trench media. Ninety seven viable samples contained 2% of Type IIIb systems, 3% of Type IIIg systems (chamber/conventional), 20% of Type IIIg systems (EZ-Flow/conventional) and 2% of Type IIIgb systems. These 32 systems accounted for 33% of the Type III systems for which system type data were available.

5.4 System Age

The study sample included less than 1 year old systems to 51 year old system. Thirty nine percent of systems were <1 year to 10 year old. The system age group 11 to 20 year old comprised 31% of total population. The percentages of system that belong to age group 21 to 30 and 31 to 40 were 14% and 11% respectively. The relationship between system age and failure rate is shown in Table 5-5. Failure rate increased with increasing system age. However, no failing systems were observed in systems 40+ old. This might be due to the small number of older than 40 years systems in the study sample.

Table 5-5: Septic system failure rate at different age groups.

System age (Years)	Number of sites			Failure rate (%)
	Not failed	Failed	Totals	
<1 -10	37	1	38	2.6
11-20	29	1	30	3.3
21 -30	12	2	14	14.3
31 -40	9	2	11	18.2
40 - 50	3	0	3	0.0
51-60	1	0	1	0.0
Total	**91**	**6**	**97**	

5.5 Site Maintenance

Relationship between nature and condition of vegetative covers, encroachments on system area and surface water diversion from the system on failure rate is presented in Table 5-6.

Site maintenance - vegetative cover

Vegetative covers on study sites, i.e. drainfield, were categorized into three groups: grassed, wooded and mixed (grass and wood). The grassed category was further classified into three groups based upon condition of lawn cover. Grassed site within group good, fair and poor represents well maintained green lot, lawns with patched of grass and bare soil, and mostly bare soils respectively. Approximately 88% of sites were grassed (62% good, 35% fair and 3% poor). All failing systems had fair grassed vegetative cover.

Table 5-6: Relationship between site maintenance and failure rate.

Lot maintenance		Number of sites			Failure rate (%)
		Not failed	Failed	Total	
Vegetative coverage	Grassed/Good	51	1	52	1.9
	Grassed/Fair	25	4	29	13.8
	Grassed/Poor	3	0	3	0.0
	Wooded	6	0	6	0.0
	Grassed + wooded	5	1	6	16.7
	Total	**90**	**6**	**96**	
Encroachment	Yes	18	1	19	5.3
	No	73	5	78	7.1
	Total	**91**	**6**	**97**	
Surface water diversion	Yes	35	0	35	0.0
	No	42	6	48	12.5
	Total	**77**	**6**	**83**	

Site maintenance – Encroachment (unauthorized uses)

Alternative uses of the area devoted to the on-site treatment system must be restricted to ensure proper operation of the system. Some kind of unauthorized uses over on-site treatment system area was found in 20% of the study samples. Major types of encroachments found were structures and driveways. Structures included outbuildings, sheds, garages, and the like. Failing rate with and without any encroachment were 5.3% and 7.1% respectively (Table 5-6).

Site maintenance – Surface water diversion

Surface water diversion from the system is one of the major site maintenance tasks that system designer and or installers and homeowner should consider. Surface water can affect system performance by increasing the amount of additional water that has to flow down through the soil along with the wastewater that comes from the house, if not diverted away from. The area for a drainfield needs to be selected and modified as needed to minimize surface water accumulation over the trenches. Study sites with surface water diverted is 16% less than the sites without surface water diversion. Hundred percent of the failing systems did not have surface water diversion from drainfield area (Table 5-6).

APPENDIX - A

Surface Hydraulic Failure Rates of On-Site Systems: Failure Rate Methodology Manual to Assess Reliability

Michael T. Hoover, Ph.D., Soil Science Dept., North Carolina State University, NC Cooperative Extension

Failure rate methodology manual outline:

1. What is an on-site wastewater system and how do they function
2. Why are surface hydraulic failure rate and system reliability studies beneficial?
3. Surface hydraulic failure rate scientifically sound methodologies
    - Principles and steps to plan scientifically sound failure rate studies
    - Methods and processes to implement dependable failure rate studies
4. Results from scientific studies
    - Demonstration of use of the failure rate methodology in recent studies
    - Results from broad-scale failure rate studies
    - Other sources of surface failure rates and system reliability data

This document currently focuses upon Sections 1, 2 and 3 above, at this point in time. The extent and details of this manuscript will be expanded, over time, to include more specificity and research methodology details for each aspect of planning and conducting failure rate studies. The manuscript will also more fully address Sections 3 and 4 above, as the document evolves throughout this project. This manuscript, once finished, will define a scientifically sound methodology to be used for assessment of on-site wastewater system performance via failure rate studies. Once Section 4 is completed it will also be a source for lessons learned in other similar studies throughout North Carolina and the country regarding those factors and under what conditions have the most significant effect upon on-site wastewater treatment system failure. Thus the manuscript will provide the methods and process to establish sound and useful failure rate studies. This methodology manual, and particularly parts number one (1), two (2) and three (3) described above, is a necessary step to properly prepare for the failure rate assessment to be implemented in this watershed as a part of this project as early as next spring.

1. What is an on-site wastewater system and how do they function?

What is an on-site wastewater treatment system?

- Traditionally -- includes a septic tank, drainfield and the soil beneath the drainfield that all function via gravity flow.
- Alternatively - system sometimes includes advanced pretreatment technologies and/or improved distribution methods.
- Septic tank, distribution device (D-box), drainfield and soil beneath the drainfield are shown.

- 3-D view shown in Figure 1
- Cross-sectional, longitudinal view shown in Figure 2

How do these systems function?

- Sewage flows from the home or other facility into a septic tank where the larger solids are retained,
- The liquid effluent is distributed to the drainfield via flowing through a distribution device,
- This effluent is temporarily held with the trenches until it is absorbed into the soil
- During downward flow through aerobic unsaturated soil the treatment processes occur removing many contaminants,
- Some contaminants, for instance nitrogen, are not removed to any great extent in the soils usually sought out and preferred for pathogen removal purposes,
- The treated wastewater flows through the water table and into the saturated zone, i.e., a groundwater aquifer, where it is later withdrawn for use in a well, or
- The groundwater flows down gradient to aquifer discharge points, such as streams, rivers, lakes, etc. where it enters water bodies as base flow or as surface seeps adjacent to the water bodies .

Where do failures occur?

- Failures can occur hydraulically or via performance malfunction with resultant discharges of untreated sewage at many locations or with poorly treated sewage including the following.
- Hydraulic failures
    - backup of sewage into the home,
    - discharge of sewage over the system and above the
        - supply line from the home to the tank,
        - the tank itself,
        - the line between the tank and the distribution device,
        - the lines between the distribution device and the drainfield and
        - the drainfield,
    - downhill of the drainfield
- Un-permitted sewage discharges via a “straight pipe” including
    - raw domestic sewage from the entire facility in a ditch,
    - partially or untreated sewage as graywater in a ditch, or
    - direct discharge to the ground surface or to a stream, river or other water body.
- Inadequately treated sewage discharged through the soil and into the groundwater.

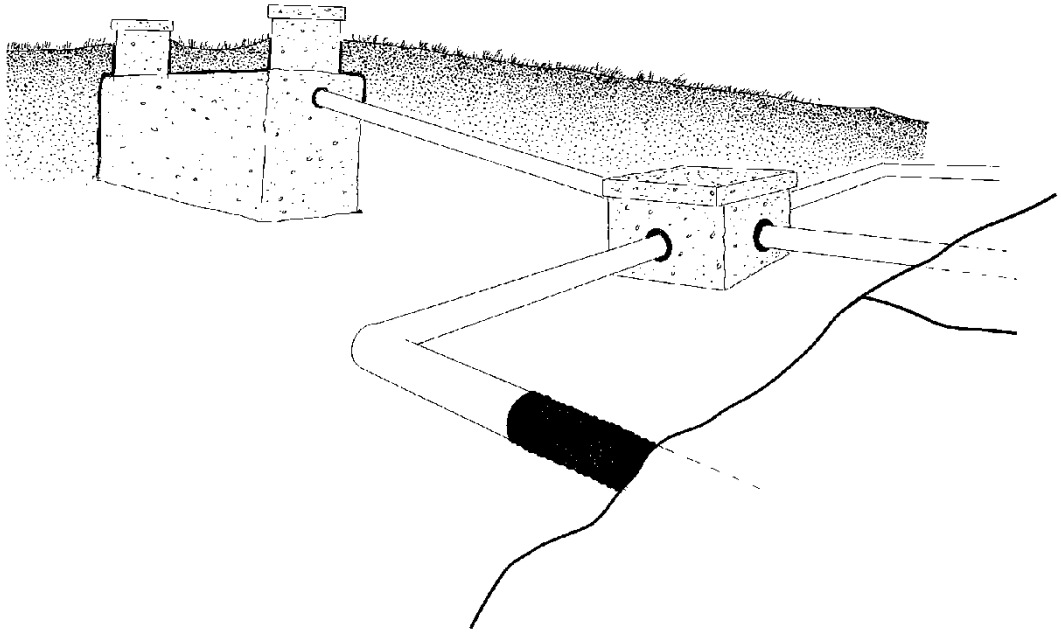

Figure 1. Three dimensional view of conventional septic system showing tank, distribution device and supply lines leading into the drainfield.

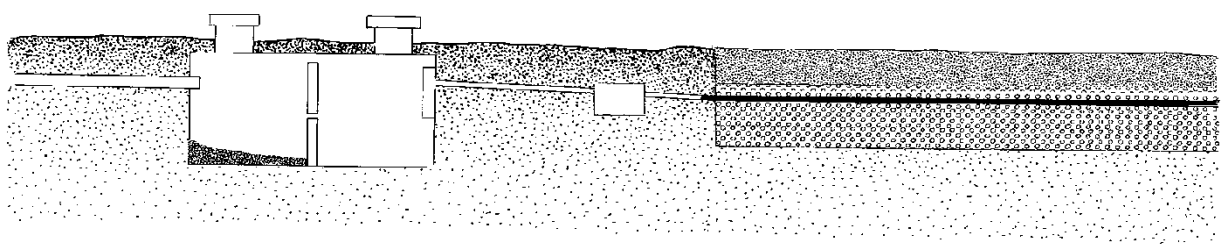

Figure 2. Cross-section, longitudinal view of conventional septic system showing septic tank, distribution device, a longitudinal section of one drainfield trench and the soil beneath the drainfield.

2. Why are surface hydraulic failure rate and system reliability studies beneficial?

- Difficulty and expense of implementing replicated side-by-side field research for numerous wastewater, soil and climatic conditions.
- Surface failure rate studies can be used to assess the performance reality of on-site systems
    - Determine how well systems work after a number of years in real-life use?

    - Evaluate how reliable various systems are under a specified range (e.g. soil type, loading regime, flow, etc.) of real-life operating conditions?
- Compare performance of technologies under the same climatic and/or soil conditions (comparison study).
- Evaluate longevity and determine the effects of factors that are thought to influence system function, performance and/or longevity.

3. Surface hydraulic failure rate scientifically sound methodologies

➢ Principles and steps to plan scientifically sound failure rate studies

Four phases to a scientifically sound failure rate study (or field survey) – 42 steps

- Phase 1: Planning and Study Design
    - Steps 1 - 15
- Phase 2: Preparation for Field Performance Assessment
    - Steps 16 - 27
- Phase 3: Study Execution and Data Collection
    - Steps 28 - 39
- Phase 4: Data Analysis and Report Preparation
    - Steps 40 – 42

Phase 1: Planning and Study Design (Steps 1 – 15)

1. Define the problem
2. Evaluate the decisions that will need to be made after the study is completed
3. Determine the questions to be answered
4. Develop the hypothesis (and null hypothesis) to be tested
5. Determine the factors to be assessed
6. Develop a written protocol with proper statistical tests and sample size for detecting important differences
7. Have the protocol peer-reviewed
8. Study leadership via third party scientists to maintain independence from funding agency (manufacturer or regulatory)
9. Identify critical attributes of an appropriate study area (locality)
10. Determine the stratification factors to be tested or to be controlled by blocking
11. Define the study population from permit data or other datasets (determine if there are permit data summary logs or files)
12. Minimize bias during selection of the population to be studied
13. Assign every system in the population a numerically sequential number
14. Generate sets of random numbers and use to randomly select the study sample for each stratum in the population

15. Over-select the sample size to allow for unusable sites including systems with incomplete or no permit records as well as for non-viable sites (e.g. sites connected to sewer, sites that can't be found in the field, sites that have dangerous animals, etc.)

Phase 2: Preparation for Field Performance Assessment (Steps 16 – 27)

16. Collect permit data and records
17. Assign each sample site a unique identifier number for quality control during data collection and analysis
18. Define "failure" for the study in very specific terms to minimize bias during data collection and analysis
19. Plan to evaluate the system of interest (the treatment) under the same weather conditions as the experimental control (the standard for comparison)
20. Plan to conduct the field performance assessment over no more than 3-10 days (3-5 preferred) to minimize data noise from fluctuating weather conditions
21. For efficiency during the field performance assessment survey itself, reconnaissance of the sites can be conducted prior to the survey to identify their locations and viability (do not contact homeowners during this stage)
22. Use GIS/GPS, tax parcel ID, 911 address
23. Develop a field survey evaluation instrument to serve as a site specific data collection and compilation guide
24. Transfer permit data to the survey instrument
25. Prepare information packets to give to residents during the survey
26. Divide the study area into survey districts to equally distribute the workload between survey teams
27. Organize files into survey district packets for each team and include GPS locators, GIS locator maps, reconnaissance data and/or detailed field maps for each survey district packet along with field data collection methods and interview instructions

➢ Methods and processes to implement dependable failure rate studies

Phase 3: Study Execution and Data Collection (Steps 28 – 39)

28. Utilize teams for QA/QC during the field performance assessment
29. Train teams together for QA/QC
30. Use mock practicum site(s) for QA/QC
31. Disperse teams and begin data collection
32. Use a one-pass approach for evaluation
33. Use single-blind survey for QA/QC
34. Construct teams to include multi-agency representation for QA/QC
35. Make joint decisions as a team
36. Type of data collected can include system type, water supply, installation date, system location, system inspection data, as-built data, soils data from field assessment, soils data from permit files, number of bedrooms, number of occupants, system history, ponding levels, system performance, failure (Y/N), etc.

37. Data collected includes site performance data, permit data and questionnaire/interview data
38. Use a quality control team to re-assess performance of approximately 10-20% of systems
39. For failing systems observed during the survey, use FACTSS process to determine the causes of failures and assess the extent to which the observed hydraulic performance is due to siting, design, inherent technology factors, installation and/or operation, use and maintenance

Phase 4: Data Analysis and Report Preparation (Steps 40 – 42)

40. Assess system performance relative to system type, stratification or blocking factors, climate, soil conditions, landscape position and topography, design, permitting process, installation, operation and maintenance, etc.
41. Have final report peer-reviewed
42. Publish the results, preferably in a journal, if at all possible

APPENDIX - B

Granville-Vance District Health Department

Lisa M. Harrison, Health Director
Post Office Box 367
Oxford, North Carolina 27565

Granville County Health Dept.
101 Hunt Drive
Oxford, NC 27565
Phone: (919) 693-2141
Fax: 919-693-8517

Vance County Health Dept.
115 Charles Rollins Road
Henderson, NC 27536
Phone: (252) 492-7915
Fax: (252) 492-4219

Date: September 7, 2012

To: Granville County Property Owners

Re: Granville County Septic System Study/ October 29-31, 2012

Your property has been chosen at random for inclusion in the 2012 Granville County septic system study. This study was mandated by recent state legislation (Senate Bill 1020) enacted to protect and improve the water quality of Falls Lake. Septic systems have been identified as one source of nutrients that may contribute to water quality problems in Falls Lake. Each year a number of properties located within the Falls Lake Watershed must be randomly selected and the performance of their septic system evaluated.

This study is scheduled to be conducted between October 29th and 31st. Survey teams will visit each of the randomly selected properties, conduct a visual evaluation of system performance, and document their findings. Each evaluation should take less than 30 minutes and you do not have to be present at the time of the visit. The survey teams will be comprised of staff from the Granville County Health Department, the Cooperative Extension Service, North Carolina State University, and neighboring county health departments.

In the rare event that a septic system is not operating properly, a follow up visit will be conducted by the Granville County Health Department to identify and address the cause of the malfunction.

Following the study, a report will be submitted to the State indicating the total number of systems in the watershed, the number of systems included in the study, and the number of those systems requiring follow up visits. The results of the study will also be available to the public.

Enclosed are a questionnaire and postage paid return envelope that will help provide us with additional useful information. Please feel free to contact me at 919-693-2688, if you have any questions about the study.

Thank you for your cooperation and participation in this important study.

Sincerely,

Wallace Vaughan, R.EHS
Environmental Health Supervisor
Granville-Vance District Health Department

(919)693-2688 - Phone
(919)603-0106 - Fax
cchampion@gvdhd.org - email
P.O. Box 367 Oxford, NC 27565

2012 Field Survey of On-Site Systems
Granville County, North Carolina

Date: _____ QA/QC: _____
Evaluators: _____ / _____

Map Number: _____ Recon _____ Survey Area_____
Address: _____

Site Evaluated: Yes _____ No* _____
*Reason for not evaluating: _____
Aerial Photography Review: No indication of malfunction ____ Indication of malfunction* ____
*Site Visit Observation: _____
_____

System Permit Information (if available) **Yes or No**

Design Flow (gal/day) _____ Bedrooms: _____ Other: _____
System Type: _____ (.1961 Va) Product (IIIg): _____ Pump ____ Conventional ___
Has system been repaired: Yes____ No____
Water supply: Well _____ Public _____ Unknown_____
Comments: _____
_____

System Inspection

1. Is the location of the system evident from field observation? Yes ____ No _____
2. Is effluent surfacing over the lines or tank today (footprint test)? **Yes***____ No ____
3. Is there a straight pipe discharge? **Yes***____ No____
4. Are there indications of possible past system failure? **Yes***___ No ____
   (If '**Yes**' please answer the following questions)
   a) Evidence of recent failure? Yes ___No___
   b) Bulls-eye vegetative pattern? Yes ___No___
   c) Bare soil surface with algae? Yes___ No __
   d) High grass/veg. over tank/lines? Yes___ No___
   e) Green plume down slope of line? Yes___ No___
   f) Soft mushy soil over tank/lines? Yes___ No___

Comments: _____
_____

* (***Please show location and extent on aerial photograph***)

General Information

Vegetative Cover

Grassed _____ (*Condition: Good* _____ *Fair* _____ *Poor* _____) Wooded _____
Is surface water diverted away from the system? Yes ____ No_____

Encroachments

Driveway ___ Pavement ____ Structure____ Patio ____ Landscaping ____ Other ____
Evidence of system repair: Yes_____ No _____
Septic system location: Backyard _____ Front yard ____ Side yard _____
*Comments:*_____

Granville-Vance District Health Department

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Fax: (252) 492-4219

Date:_____ Address: _____

Please complete and return this questionnaire in the envelope provided. This information will help us better understand how well septic systems are performing in Granville County. Thank you for your cooperation.

1) How old is your septic system? ___ years

2) How long have you lived in this home? __years

3) How may individuals live in the house? ___

4) Have you ever had any problems with your septic system? Yes___No____Unsure____
   If yes, was the wastewater:
   Surfacing in the yard ____
   Backing up into the house/draining slowly ____

   If yes, does the problem appear to be related to:
   Rainfall ___
   Guests' ____
   Laundry ____
   Season of the Year ____ (season)

5) Has the septic system been repaired? Yes____ No ____ Unsure ____
   If yes, when was the system repaired? _____

6) Has the septic tank been pumped? Yes ___ No ___ Unsure ____
   If yes, when and how often? _____

7) Have you modified your water use to avoid septic system problems? Yes___No___

8) Do you try to keep harsh chemicals and grease/oil out of the system? Yes ___ No ___

9) Would information on how to maintain your septic system be useful? Yes___ No___

10) Are there dogs at this address? Yes____No____

APPENDIX - C

Data Summary

To be included after draft is reviewed

Homeowner Questionnaire Master data