Virginia Cooperative Extension

An Assessment of Residential Practices Affecting Water Quality in the Northern Shenandoah Valley

June 2003

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

VIRGINIA STATE UNIVERSITY

An Assessment of Residential Practices Affecting Water Quality in the Northern Shenandoah Valley

Robert A. Clark
Extension Agent, Agriculture

C. Corey Childs
Extension Agent, Agriculture

Franklin A. Bruce, Jr.
Extension Specialist, Program Evaluation

Table of Contents

Electronic copies of this report can be found at the following website:
http://www.vwrrc.vt.edu/publications/special_reports.htm

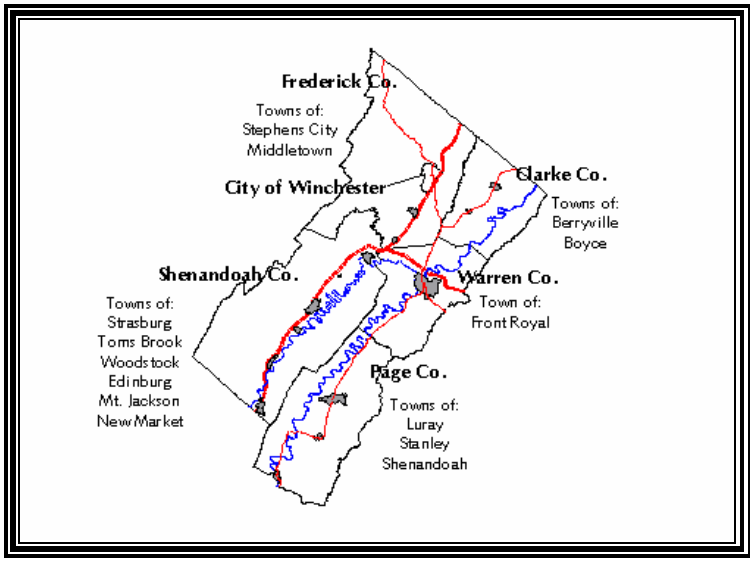
Cover Photos Courtesy of Kansas State University and Sharon Clark.

Acknowledgements

We wish to express our deepest gratitude to the following individuals/groups for their contributions to this project: the 2001 Environmental Science Class at Shenandoah University, Pure Water 2000 Forum, Virginia Water Resources Research Center, Mr. Bob Carlton, Mrs. Jan Gurtner, Mrs. Johan Guss, Mrs. Ruth Stultz, Mr. George Hadeler, Dr. Greg Mullins, Dr. Greg Eaton, Mr. Frank Baxter, and the Northern Shenandoah Valley Master Gardeners.

Overview

The Northern Shenandoah Valley (NSV) consists of Clarke, Frederick, Page, Shenandoah, and Warren Counties, and the City of Winchester. Over the past two decades, there have been many activities to improve water quality within the region. While progress can be credited to the efforts of many groups, many have begun to consider whether efforts focused at the residential sector would result in noteworthy benefit to water quality. Homeowners can contribute impairments to water quality from nutrients (fertilizer, pet waste, septic tanks, etc.), fecal coliform bacteria (pet waste and failing on-site wastewater treatment), and pesticides (from lawn and garden pest control). However, it has not been well understood, nor documented, whether or not activities associated with residential life in the NSV has any appreciable effect on water quality.



Map of Study Area
Photo courtesy of Lord Fairfax Planning District Commission.

Aveni et. al (2001) piloted an educational program to residential homeowners in the eastern portion of Virginia. This educational program is described in Extension publication 448-113, "The Chesapeake Bay Residential Watershed Water Quality Management Program." This program was able to improve water quality by reducing homeowner lawn fertilization rates.

2002 Northern Shenandoah Valley Master Gardener Class

Purpose

The purpose of this survey was to document the activities/practices of homeowners within the NSV that can affect water quality.

Methods

To accomplish this purpose, the senior environmental science class at Shenandoah University was contacted and agreed to develop a questionnaire which would be mailed to selected residents of the NSV. The questionnaire was designed to assess residential life activities that could impact water quality.

Shenandoah University
Photo courtesy of Shenandoah University.

After developing the survey, it was pilot tested by individually polling 67 customers at Home/Yard and Garden centers in the City of Winchester. It was found that most (90%) of the participants in the pilot survey did not provide interpretable answers to the question relating to the amount of fertilizer used on their lawns. In addition, 27 percent of the respondents who had lawns answered the question "how much lawn space do you maintain" as either greater than 10 acres or no response. The survey was modified based on recommendations and other knowledge gained from the pilot process. Modifications included shortening the survey to fit a single sheet of legal paper (front and back), adding an informational needs assessment, and deleting all questions relating to size of yards and amount/type of fertilizer.

Sample

Lists of homeowners' addresses were obtained from each of the counties included in the study area (Clarke, Frederick, Page, Shenandoah, and Warren) and from the City of Winchester. The lists of addresses obtained from Clarke, Page, Shenandoah, and Warren Counties, and the City of Winchester were exclusively for single family dwellings. However, Frederick County did not have a system for distinguishing between single family dwellings, duplexes, and townhouses. Therefore, the selected homeowners in Frederick County may have included some duplexes and townhouses.

A stratified probability sample was drawn by randomly selecting homeowners from each locality. It was decided that a precision rate of $\pm$ 0.03 would be satisfactory, which meant that a sample size of approximately 1,090 homeowners should be drawn. Because response rates to mailed surveys are usually low, we doubled the number of households sampled. A total number of 2,234 surveys were mailed out. See Table 1.

Table 1. Localities, Relative Proportions by Population, and Number of Responses to the Survey by Locality.					
	Number of Dwellings by Locality	**Percent of Population**	**Surveys Mailed by Locality**	**Responses to Surveys by Locality**	**Percent of Returned Surveys by Locality**
Clarke*	5,600	9%	220	88	11%
Frederick**	18,274	28%	540	194	24%
Page*	8,665	13%	322	109	14%
Shenandoah*	14,165	22%	472	187	24%
Warren*	11,353	18%	430	137	17%
Winchester*	6,309	10%	250	65	8%
Other***	0	0%	0	14	2%
Total	64,366	100%	2,234	794	100%
* Dwellings include Single Family Dwellings.					
** Dwellings include Single Family Dwellings, Duplexes, and Townhouses.					
*** Individuals who Reside Outside of the Study Area but Have a Dwelling Within the Study Area.					

Procedure

On January 3, 2002, the survey was mailed with a reminder postcard mailed 14 days after the initial survey mailing. Eleven individuals asked for another survey and were sent another one. Survey responses were accepted through April 1, 2002. A total number of 794 usable surveys were received for a response rate of 36 percent.

For the sample size of 794, the precision was calculated for a 95 percent confidence level and found to be $\pm$ 3.6 percent (Smith, 1983; Yamane, 1973).

Percentages reported for individual regions (e.g., Clarke, 52% of the homes fertilize their lawns) each have different precision rates since sample sizes for each region differed as did the region's respective population (See Table 1). All precision rates for the entire NSV and for individual regions were calculated for a 95 percent confidence interval. That is, we are 95 percent confident that the population percentages fall within $\pm$ of the precision rates calculated for the respective sample percentages within a particular area/region. See the area and regional precision rates reported in Tables 2, 3, 4, and 5.

Data provided from 794 homeowners responding to the survey were coded and hand entered into an electronic data management system (Microsoft Access) for data analysis. Data analysis was conducted using SPSS Version 11.5.

Findings, Discussion, and Implications

Lawn Care

The survey found that 61 percent of the respondents in the NSV use fertilizer on their lawns at least once every four years. See Table 2. Also, fertilizer use was found to be generally consistent across home settings (rural agricultural areas versus rural non-agricultural areas versus urban/town areas) and across County/City. Approximately 35 percent of the respondents reported fertilizing their lawns at least one or more times per year. Twenty-six percent of the respondents reported fertilizing their lawns once every two to four years. No attempt was made to quantify the amount of fertilizer that homeowners use nor the timing of fertilizer applications.

Spreading Fertilizer on a Lawn

Approximately 29 percent of the respondents who fertilize their lawns said they have taken a soil sample. Fifty-one percent of all respondents indicated they have a need for information on lawn care. See Table 3. Of those who use fertilizer on their lawns, 58 percent indicated that they have a need for information on lawn care while 33 percent indicated they have no need for lawn care information. See Table 3.

Eight percent of homeowners over the entire NSV reported using a lawn care service. As might be expected, the City of Winchester comprises the largest percentage of these. Within the five counties, 79 percent of the respondents who reported they were using a lawn care service were either in rural/ non-agricultural areas or in urban/town areas.

It is likely that educational efforts about lawn fertilization and septic system maintenance focused to homeowners in the NSV would result in water quality benefits. A homeowner and lawncare personnel education program in the NSV that reached 3,000 homeowners who presently use fertilizer could potentially lower nitrogen fertilization rates by over 45,000 pounds per year. This assumes an average yard size of 10,000 square feet and a reduction of 1.5 lbs. N per 1,000 square feet (no data are available on homeowner yard size).

Major Finding:

There are about 64,000 single-family dwellings in the Northern Shenandoah Valley. Approximately 22,400 of these dwellings apply fertilizer to their lawns at least once a year and another 16,640 apply fertilizer at least once every two to four years.

Currently, no data are available on the amount of phosphorus (P) reductions that might be possible through this type of educational program. From 1998 through June 2002, the Virginia Tech Soil Testing Laboratory analyzed 299 soil samples from lawns in the NSV. Only 19 percent of these samples exceeded 55-PPM Mehlich 1 P. Soils that have greater than 55-ppm Mehlich 1 P are classified as “very high” by the Virginia Tech Soil Testing Laboratory. Soils that

Table 2: Summary of Survey Results*							
	Total	**Clarke**	**Fred.**	**Page**	**Shen.**	**Warren**	**Winch.**
*Precision***	*± 3.6%*	*± 11%*	*± 7%*	*± 10%*	*± 7%*	*± 9%*	*± 12%*
Lawn Care							
Homes with Lawns	95% 756	96% 84	96% 186	95% 104	94% 175	95% 130	100% 65
Homes that Fertilize Their Lawns	61% 484	52% 46	70% 135	53% 58	59% 111	57% 78	72% 47
Percent of Homes that Fertilize Their Lawns that Test Soil	29% 138	52% 24	25% 34	24% 14	23% 25	26% 20	38% 18
Homes that Use Weed Killer on Their Lawns	43% 343	33% 29	46% 89	37% 40	39% 73	42% 57	74% 48
Homes that Use Lawn Care Service	8% 63	3% 3	9% 18	3% 3	7% 13	4% 6	26% 17
Vegetable Garden							
Homes that Have a Vegetable Garden	38% 298	43% 38	32% 63	38% 41	53% 100	28% 38	22% 14
Percent of Homes that Have a Vegetable Garden that Soil Test	26% 77	34% 13	19% 12	20% 8	37% 37	11% 4	7% 1
Waste Management							
Homes that Recycle	70% 558	72% 63	64% 124	54% 59	74% 138	74% 102	94% 61
Homes with a Mulch Pile or Compost Pile (Leaves, Grass, and Other Organic Material)	35% 281	52% 46	39% 75	23% 25	34% 63	35% 48	28% 18
Homes with On-site Septic	60% 480	80% 70	54% 104	64% 70	74% 138	64% 87	6% 4
Homes with Dog or Cat	63% 501	76% 67	66% 129	65% 71	53% 99	67% 92	57% 37
Homes that Leave Pet Waste in the Yard	30% 237	43% 38	28% 54	32% 35	27% 50	34% 46	17% 11

* Regional percentages and numbers of residents reported are relative to a specific region. For example, 94 percent of the respondents (175) residing in Shenandoah County reported having a lawn.
** Precision rates were calculated separately for the entire NSV and individual regions

test very high have enough P to supply the P needs of most crops without any additional P fertilizer. Applying P fertilizer to soils exceeding 55-ppm Mehlich 1 P, increases the probability of elevated levels of P in surface runoff. These soil tests, however, may not be representative of all yards in the NSV. Furthermore, homeowners with low soil test P levels who are over-applying or mis-applying P may still have a negative effect on water quality. A homeowner educational program could be designed to quantify reductions in nitrogen and phosphorus fertilizer use and improve fertilizer application techniques.

Pesticide Use

Forty-three percent of the respondents report using a weed killer on their lawns within the past two years. More people in the City of Winchester appear to be using weed killer than people in the counties (74% for Winchester versus 33-46% for the counties). It is unknown if this pesticide use is causing any water-quality problems. Fifty-four percent of respondents who have used a weed killer on their lawns within the past two years indicated a need for more information on lan care.

Table 3: Summary of Informational Needs of NSV Residents (N=794).

Precision ± 3.6%	No Need	Some Need	Great Need	No Opinion
Selection of Landscape Plants	30%	35%	18%	16%
Pest Management in Trees and Shrubs	28%	35%	19%	18%
Lawn Care	33%	36%	15%	16%
Growing a Conventional Vegetable Garden	47%	23%	10%	21%
Maintenance/Care of On-site Sewage Disposal System	53%	19%	7%	20%
Backyard Composting	48%	24%	8%	21%
Recycling Solid Waste (Cans, Paper, Plastic, etc.)	55%	19%	4%	22%
Reducing the Amount of Solid Waste Generated in Home	42%	28%	8%	22%
Backyard Wildlife Habitat	38%	26%	17%	19%
Assessing the Safety of Your Home Water Supply	36%	26%	19%	18%
Steps Homeowner Can Take to Improve the Environment	22%	39%	22%	18%

Vegetable Gardens

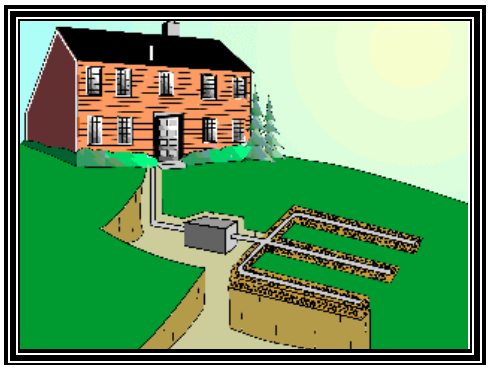
Approximately 38 percent of the respondents reported they have a vegetable garden. Twenty-six percent of the people with a vegetable garden reported they have tested their soil. From 1998 through June 2002, the Virginia Tech Soil Testing Laboratory analyzed 353 soil samples from vegetable gardens in the NSV. Fifty-eight percent of these samples exceeded 55-PPM Mehlich 1 P. The needs assessment indicates that 33 percent of all respondents indicated a need for information related to conventional vegetable gardening while 53 percent of respondents who currently have a vegetable garden indicated a need for more information.

Solid Waste Management

Seventy percent of the respondents reported that they recycle (cans, paper, plastic, etc.). This number was fairly consistent across all areas with the City of Winchester reporting the highest percentage of homes recycling (94%). This survey did not quantify the amount of potentially recyclable materials that people recycle. For example, a respondent who "recycles" could recycle anywhere from a few cans to all of their cans, paper, and plastic. Only 23 percent of the respondents indicated a need for receiving more information about recycling.

Septic System Maintenance

This survey found that 60 percent of respondents (which represent approximately 38,400 homes in the NSV) reported having an on-site sewage disposal system. Virginia Cooperative Extension publication titled "Septic System Maintenance" provides recommendations for pumpout frequency. Recommendations in that publication are based on the size of the tank and number of people who reside in the dwelling (VCE, 1995). Table 4 summarizes survey responses based on that publication. For example, a household with a 1,250-gallon septic system that has four people residing in the home should pump every three years. Conversely, a household with a 1,250-gallon septic system that has only two people residing in the home need only pump once every seven years. Based on these recommendations, this survey found that 59 percent of NSV homeowners who have an on-site sewage disposal system are likely pumping their tank as recommended. Table 5 summarizes these data on a county-by-county basis. During 1997, an assessment of the septage disposal situation was conducted by comparing the total number of septic tanks and cesspools in Clarke, Frederick, Page, Shenandoah, and Warren Counties with the amount of septage received at septage receiving stations. These data indicated there were about 35,700 septic tank or cesspool sewage disposal systems in Clarke, Frederick, Page, Shenandoah, and Warren Counties (Steiffel, 1997) and about 3,450 were pumped in 1996 (Clark, 1997).



Typical Septic System
Photo Courtesy of the New Jersey Department of Environmental Protection.

Major Finding:

This survey found that 59 percent of homeowners who have a septic system in Clarke, Frederick, Page, Shenandoah, and Warren Counties, and the City of Winchester are likely pumping their tanks as recommended. Conversely, 34 percent of homeowners (about 13,000 homes) likely need to pump their septic systems more frequently.

In terms of information needs, 47 percent of the respondents who said they have an on-site wastewater treatment system and never pumped their septic systems indicated they have a need for information on septic system maintenance. Forty percent of the respondents who pump indicated a need for information. See Table 3.

There are numerous resources available to educate homeowners about proper management of on-site wastewater treatment systems. Many of these references can be located under the *Housing and Farm Structures* section of the Virginia Cooperative Extension Web site www.ext.vt.edu/resources/. A list of some of these materials includes:

Table 4: Homes with On-Site Wastewater Treatment Systems* (Entire Northern Shenandoah Valley except Winchester)		
	Percent **	**Number**
Likely Pump as Recommended	**59%**	**269**
Don't Know How Often they Pump	**8%**	**36**
Likely Need to Pump More Often	**34%**	**154**
*Assumes an average septic system size of 1,250 gallons. ** Precision ± 5%		

- Alternative On-site Wastewater Treatment and Disposal Options. Publication 448-403.
- Individual Homeowner & Small Community Wastewater Treatment & Disposal Options. Publication 448-406.
- Maintenance of Low Pressure Distribution Septic Systems. Publication 448-402.
- Maintenance of Mound Septic Systems. Publication 448-401.
- Planting on Your Septic Drain Field. Publication 426-617.
- Septic System Maintenance. Publication 448-400.
- Virginia Farmstead Assessment System: Household Wastewater Treatment and Septic Systems. Publication 442-903.

Table 5: Summary of On-Site Wastewater Treatment by County					
	Shenandoah n=135	**Page n=68**	**Clarke n=69**	**Frederick n=102**	**Warren n=85**
Precision	± 9%	± 12%	± 12%	± 10%	± 11%
Likely Pump as Recommended	62%	44%	72%	57%	56%
Don't Know How Often They Pump	8%	7%	6%	5%	13%
Likely Need to Pump More Often	30%	49%	22%	38%	31%
*Assumes an average septic system size of 1,250 gallons.					

Summary

Educational efforts focused on lawn/garden fertilization and septic system maintenance in the NSV will likely render significant water quality benefits. The benefits would include reduced nutrient and fecal coliform loading on both ground and surface waters. The survey also found a large number of homeowners use pesticide on their lawns. There may be some water quality benefit from homeowner educational efforts focused on homeowner pesticide use and vegetable gardening techniques. However, more information is needed which documents a water quality problem from homeowner use of pesticides.

References

Aveni, M., K. Carter, S. Craik, W. Kerns, R. Prunty, and D. Relf. 2001. The Chesapeake Bay Residential Watershed Water Quality Management Program: Reducing Non-Point Source Pollution through Proper Lawn Care Practices. Virginia Cooperative Extension, Blacksburg, VA. Publication 448-113.

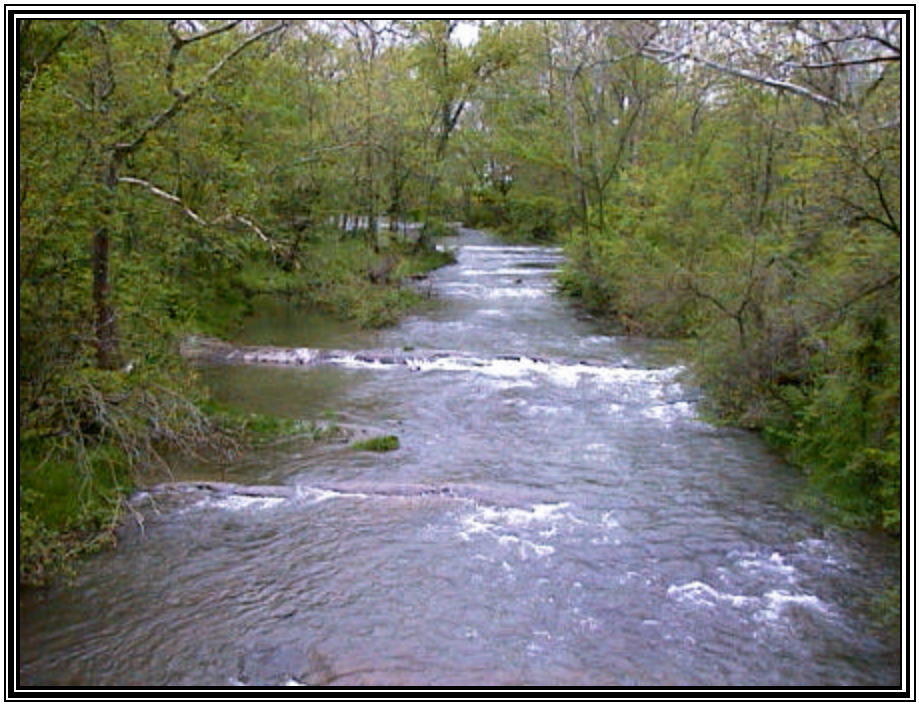
Clark, R. A. 1997. Unpublished Data: Septage Disposal Situation: Shenandoah, Clarke, Frederick, Warren, and Page Counties. Virginia Cooperative Extension. Blacksburg, VA.

Smith, M. F. (Ed.) (1983, October). Sampling Considerations in Evaluating Cooperative Extension Programs. (Available from Florida Cooperative Extension Service).

Steiffel, S. 1997. Personal Communication. Environmental Health Manager, Virginia Department of Health. Winchester, VA.

VCE. 1995. Septic System Maintenance. Virginia Cooperative Extension. Blacksburg, VA. Publication 448-400.

Yamane, T. (1973). Statistics: An Introductory Analysis (3rd edition). New York: Harper and Row.



Mill Creek in Shenandoah County