The Virginia Small Water Systems Survey: An Assessment of Public Health Performance Appraisals

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EXECUTIVE SUMMARY

In 1994 the Environmental Protection Agency (EPA), recognizing the unique problems that face small water supply systems, asked the National Research Council (NRC) to perform a study of these problems and to make recommendations for minimizing them. The results of the study were reported in the 1997 publication, *Safe Water from Every Tap: Improving Water Service to Small Communities.* NRC's primary recommendation regarding these problems was to require Public Health Performance Appraisals (PHPA) of all small water systems. The PHPA consists of documenting and evaluating the following:

(1) Issuance of health orders
(2) Water quality
(3) Certification of operators
(4) Sanitary surveys
(5) Water system plans

The NRC recommends a water system plan contain:

(1) *Evaluation of existing system characteristics*
(2) *System standards*
(3) *Analysis of the supply source*
(4) *Source protection*
(5) *Operational and maintenance program*
(6) *Emergency response program*
(7) *Quality of supplied water*
(8) Improvement program
(9) Financial viability

To assess the potential value of the Public Health Performance Appraisal (PHPA) process to Virginia, a survey was performed of all Virginia small water system permit holders. An 8 page, 85-question survey was mailed to each of the 3781 small water system permit holders in Virginia. The intent was to collect information regarding each of the areas of the PHPA and to use this data to determine if the weaknesses suggested by the NCR report held true in Virginia. Additionally, it was intended that the assumptions made by the report could be somewhat tested by the actual Safe Drinking Water Act violations reported on the survey by the respondents.

The Virginia Small Water Systems Survey analysis identified several weaknesses among Virginia's small water systems. Of notable concern were the areas of future planning, financial management by non-community water systems, preventative maintenance, and emergency preparation. It was noted that significant relationships exist between the SDWA violations and financial management, preventive maintenance, operations, and emergency preparation practices. However, this relationship is somewhat counter

intuitive in that, systems that show higher levels of these practices actually have violated the SDWA more frequently. It is likely that this finding is the result of improvements in management practices following a violation. In other words, if a system is cited for a violation, they respond by improving their management practices in these four areas presumably to prevent future violations.

Of additional interest is the role that operator certification plays in water systems. Systems with at least one certified operator reported a higher level of system knowledge, an increased level of preventive maintenance practices, and the use of emergency preparation practices. This lends support to a more comprehensive operator certification requirement that would encompass all small water systems.

Finally, the survey supported the usefulness of record keeping. Systems with better records demonstrated a higher level of system knowledge. Additionally, systems with records pertaining to the regulation requirements were significantly less likely to have violated the SDWA. This would support the NCR's recommendation for increased system record keeping and planning.

1. Introduction

In 1994 the Environmental Protection Agency (EPA), recognizing the unique problems that small water supply systems face, asked the National Research Council (NRC) to perform a study of these problems and to make recommendations for minimizing them. The results of this study were reported in the 1997 publication, *Safe Water from Every Tap: Improving Water Service to Small Communities.* The recommendations of the study were derived through interviews with industry representatives, information from published literature, and the expertise of the NCR's Committee on Small Water Supply Systems. The recommendations were not, however, substantiated with any empirical data.

1.1. Public Health Performance Appraisals

One of the primary issues addressed by the NRC report was the long-term sustainability of small water systems. NRC's primary recommendation regarding this issue was to require public health performance appraisals (PHPA) of all small water systems. The PHPA consists of documenting and evaluating the following:

1) *Issuance of health orders*: Any water-quality-related health violation as determined by the Department of Health.
2) *Water quality compliance*: Records of non-compliance with monitoring and maximum contaminant level (MCL) water quality standards of the SDWA.
3) *Certification of operators*: The number and level of operator certification.
4) *Sanitary surveys*: On-site visits by the regulatory agency to assess facility condition, source protection measures, and operator competence.
5) *Water system plans*: A comprehensive plan that includes an overview of present and future performance criteria.

1.1.1. Water System Plan

The water system plan is a comprehensive assessment of a system's existing and future physical, operational, managerial, and financial performance criterion. The intent of the water system plan is to improve the level of knowledge system operators have about the water systems' existing situation, to reveal any potential weaknesses that may exist, and to encourage examination of future needs. The NRC recommends that a water system plan contain the following:

1) *Evaluation of existing system characteristics*: An inventory of all system facilities and their condition.
2) *System standards*: A listing of all federal, state, and other standards that the system is required to meet.
3) *Analysis of source of supply*: Qualities or deficiencies of the existing source in terms of present and future needs, including an evaluation of possible alternative sources, such as interties with neighboring utilities.
4) *Source protection*: A program for improving and protecting source waters.
5) *Operational and maintenance program*: A documented system for operating and maintaining the facility.

6) *Emergency response program*: A plan for remedial action and notification in the event of emergency, including an analysis of potential vulnerabilities.
7) *Quality of supplied water*: A list of monitoring locations for each parameter, schedules for sampling, testing laboratories, etc.
8) *Improvement program*: A prioritized schedule for capital and operational improvements, including costs and funding options.
9) *Financial viability*: A demonstration of the system's ability to provide sufficient funds to maintain, improve, and to operate in compliance with regulations.

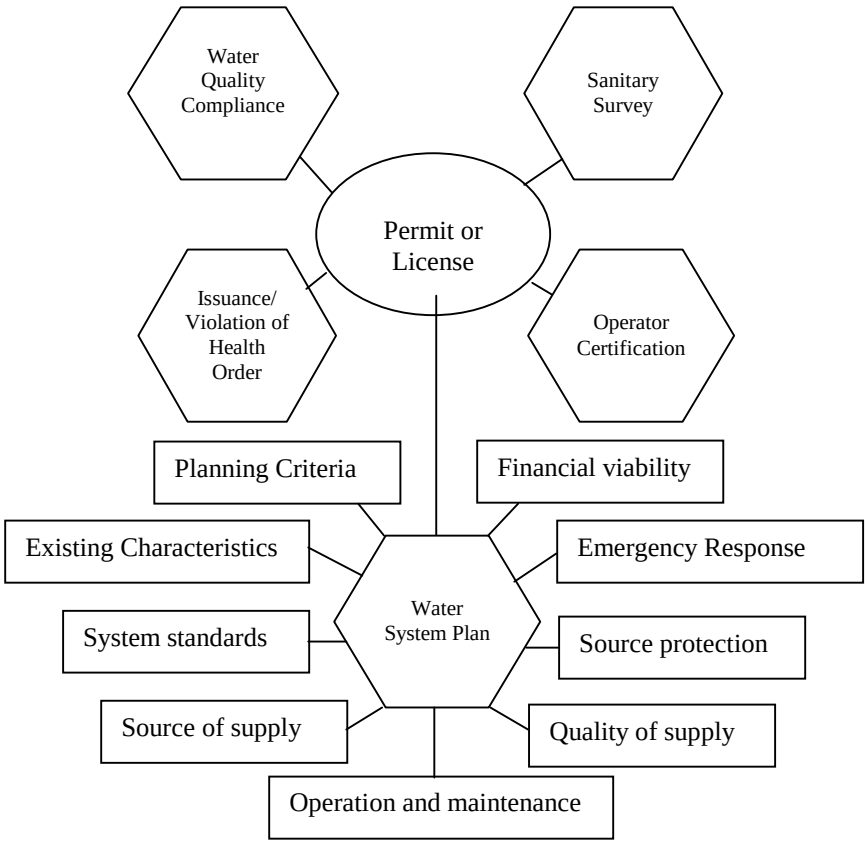

Figure 1. Public Health Performance Appraisals (Source: NRC, 1997)

Figure 1 diagrams how each of these components come together to form the public health performance appraisal. The NCR report suggests that requiring the comprehensive collection and documentation of each of these areas will improve the understanding the owners and operators have of their water system and the associated regulations, and thereby enhancing the ability of these systems to provide high quality water over the long term.

1.2. Safe Drinking Water Act (SDWA) Summary

Congress enacted the Safe Drinking Water Act (SDWA) in 1974. The SDWA was amended in both 1986 and 1996. Of particular importance to this study are the 1996

amendments. These amendments redirected the focus of the SDWA in several major ways. First, it improved the regulatory framework by establishing regulation based on data obtained on the adverse health effects of a contaminant (risk-based priority setting) and by giving the states greater flexibility in implementing the Act according to their own needs. Second, it introduced the Drinking Water State Revolving Fund (DWSRF), which substantially increased infrastructure improvement funding. Third, it provided new prevention initiatives. Specifically, it established a source water assessment program and national minimum guidelines for certifying operators of drinking water systems. Finally, it requires greater public involvement in drinking water protection (EPA, 1997).

1.2.1. Definitions

The Act regulates all public water systems. A *public water system* is defined as follows:

A public water system means a system that provide water to the public for human consumption through pipes or other constructed conveyances, if such system has at least fifteen service connections or regularly serves at least twenty-five individuals. Such term includes (i) any collection, treatment, storage, and distribution facilities under control of the operator of such systems and used primarily in connection with such system, and (ii) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system (Section 1401 of the SDWA).

Under the SDWA, public water systems are divided into three categories: community systems, transient non-community systems, and non-transient non-community systems. Community water systems serve the same population on a year round basis. Transient non-community systems serve transient populations in a specific geographic place, such as a campground or a gas station. Non-transient non-community systems supply water to at least 25 of the same people, at least six months each year but not year-round, such as a school, factory, office building, or hospital.

Additionally, water systems are categorized according to the number of people served:

Very Small Water System: serves 25-500
Small Water System: serves 501-3,300
Medium Water System: serves 3,301-10,000
Large Water System: serves 10,001-100,000
Very Large Water System: serves 100,000+

This study uses these terms through out as defined here. It specifically addresses the circumstances of all water systems in Virginia that are categorized as small and very small.

1.2.2. Requirements and regulations

The Environmental Protection Agency (EPA) was given authority to administrate the SDWA. This includes the setting and revision of national drinking water standards to which all water systems covered under the SDWA must adhere. The EPA may delegate to the states, or some other approved governmental entity such as a county, the authority

to run the day-to-day program. Where such delegation has not been made, the EPA runs the program itself. Whoever it is that acts as the "regulatory agency", or the one who receives this authority, is responsible for tracking the sample results, inspecting facilities (called sanitary surveys), and enforcing through fines, etc, the requirements of the Act. In Virginia the regulatory agency is the Virginia Department of Health (VDH).

There are three major requirements of the Safe Drinking Water Act. They are (1) Sampling and Reporting, (2) Record Keeping, and (3) Public Notification. Each water supplier is required to collect samples of the drinking water from the system. These samples have to be analyzed by a certified laboratory, and the results sent to the regulatory agency for the area the system is located. The nature of the analysis performed, the frequency of analysis, and the location from which the sample is taken, varies depending on the system and the potential contaminants. Records are maintained of the laboratory results, the person who collected the sample, the location and date from which it was taken, corrective measures, and sanitary survey reports. The public must be notified any time a SWDA requirement is violated.

Violations take two forms, Tier 1 and Tier 2. Tier 1 includes more serious violations such as the presence of a contaminant in the system in excess of the maximum level established by the EPA's national drinking water standards. Tier 2 violations are of a less serious nature, such as a failure to follow a compliance schedule. Tier 1 violations require more extensive public notice. A one-time special notice is also required to make the public aware of lead levels in the water, whether or not there is a violation of the standard requirement. Table 1 outlines these two violation types and the acceptable ways of issuing notices. All notices must contain an explanation of the violation, potential adverse health effects, population at risk, steps being taken to correct the situation, need for alternative water supplies, and suggested consumer action.

The EPA has established two different types of standards for drinking water, *Primary* and *Secondary*. Primary standards are based on health risks and are strictly enforced. Secondary standards are based primarily on aesthetic qualities such as color, smell, and taste and are not enforceable. Water that fails to meet the secondary standards is likely to be unpleasant to drink, but is not a threat to health.

The "maximum contaminant level goal" (MCLG) is one of the three primary standards. It is the level of contamination at which no adverse health effects will occur in an individual drinking the water from the system over an entire lifetime. For contaminants that are believed to be carcinogens, the MCLG, for example, is zero because it is believed there is no known safe level. MCLG's are not enforced but rather operate as goals.

Table 1. SDWA Violations

	Tier 1 Violations	Tier 2 Violations
Types	Failure to comply with an MCL	Failure to comply with a monitoring

	Failure to comply with a treatment technique Failure to comply with a variance or exemption schedule	requirement Failure to comply with a testing procedure Operating under a variance of exemption
Method of Notice	Newspaper - No later than 14 days after violation Hand or Mail delivery - No later than 45 days Electronic (TV/Radio) Media* - No later than 72 hours	Newspaper - No later than 14 days after violation

* Only if acute risk to health present

The second primary standard established by the EPA for contaminants is called simply the "maximum contaminant level" (MCL). Unlike the MCLG, this level is not a goal but is a required and enforceable level. These are established as close to the MCLG as is technically possible given the cost and available technology. It is against this standard that the samples discussed above are compared.

The third primary standard is the Treatment Technique Requirement. These requirements are imposed upon those contaminants that are difficult to measure. Instead requiring a certain maximum level, the EPA has decided to require a specific treatment practice that presumably will keep the level appropriate.

The regulatory agency has the option of adopting the EPA's standard or adopting its own requirements, provided they are stricter. They may also require operator certification, system permitting, and additional sampling. Additionally, in the event that the supplier is unable to meet a given requirement due to some major technical or financial problem, and no undue health risk is imposed upon the customers being served by the system, the agency can grant a variance. These are, however, very rare.

The regulated contaminants are grouped as follows:

1) *Microorganisms*: Include bacteria, fungi, protozoa, and viruses.
2) *Inorganic chemicals*: These are naturally occurring metals and minerals.
3) *Synthetic Organic Chemicals*: The chemicals are carbon-based and human-made. They include pesticides, herbicides, and PCBs.
4) *Volatile Organic Chemicals*: These are chemicals that travel from the water into the air, or volatize, easily.
5) *Radionuclides*: These are naturally occurring radioactive chemicals.
6) *Disinfection by-products*: These chemicals are created when disinfectants are added to water that contains organic matter, such decaying plant material.

For each contaminant group there are different sampling requirements. The requirements vary depending on whether the source is surface or ground water. In addition to the contaminant monitoring, there is also a requirement for monitoring "water quality parameters," such as pH, alkalinity, etc; which contribute to the corrosion of water pipes. Each contaminant group also has requirements for the location points where samples are taken.

In addition to specific frequencies and locations, the SDWA requires:

- Specific types of containers for each contaminant;
- Specific volumes of water collected;
- Specific temperatures at which water must be preserved;
- Amount the container must be filled;
- Duration of time sample can be held.

The water supplier has the responsibility of informing the regulatory agency about the water system sampling outcomes. Samples are due to the agency within the first 10 days of the month following the month the sample was taken. If an MCL violation occurs, the agency requires the supplier to notify them within 48 hours. Additionally, when a required sample is not taken, the regulatory agency must be notified within 48 hours. In the event that public notification is required due to some violation, these notifications must be sent to the regulatory agency within 10 days. Records must be kept for a specific duration as follows:

- Bacteriological results: 5 years
- Chemical results: 12 years
- Corrective action reports: 3 years
- Sanitary survey reports: 10 years

1.2.3. Study Variables

As part of this study, several variables related to violations of the SDWA will be used to evaluate the tenets of the Public Health Performance Appraisals (PHPA). These are general variables obtained from the EPA Envirofacts web page. They are:

- ANYMCL: This variable denotes whether a water system has had at least one MCL violation during the last five years. The value is either zero if no MCL violations had occurred, or 1 if any have occurred.
- ANYRPT: This variable denotes whether a water system has had at least one reporting and monitoring violation during the last five years. The value is either zero if no violations have occurred, or 1 if they have.
- ANYVIOL: This variable denotes whether a water system has had any violations at all during the past five years, including Reporting and/or Monitoring or MCL or Treatment technology violations. The value is either zero if no violations have occurred, or 1 if they have.
- MCL: This variable represents the actual number of violations a specific water system has had in the last five years.

- RPTMNTR: This variable represents the actual number of reporting and monitoring violations a specific water system has had in the last five years.
- TRTMNT: This variable represents the actual number of treatment technology violations a specific water system has had in the last five years.

In this study these variables are examined for relationships between violations of the SDWA and the current PHPA practices of the Virginia small water systems.

1.3. Small Water Systems

Small water systems are defined as those that serve a population of 3300 people or less. Most Public Water Systems (PWS) are small systems. Small water systems comprise 86% of all community water systems (CWS) but serve only 10% of the population who get their water from CWS. They comprise 99.5% of the non-community non-transient water systems (NTNCWS) and serve 83% of those served by NTNCWS. Finally, of all the transient non-community water systems (TNCWS), 99.7% are small or very small and provide water to 55% of those who are served by TNCWS (EPA, 1998). In total, approximately 20% of the U.S. population is served by small water systems and this number is increasing annually (NRC, 1997).

Although most small water systems provide safe drinking water, many face challenges in doing so. In fact, small systems are twice as likely to violate drinking water standards for microbes and chemicals than systems serving 10,000 or more people (NRC, 1997). One primary cause of this is the lack of capital to upgrade their facilities and to provide sufficiently for the day-to-day operation and maintenance of the system (NRC, 1997). Additionally, many small water systems are actually subsidiaries of small businesses such as restaurants and these small water systems serve only the business. As such they receive only minimal attention from owners in terms of management, operations, and maintenance. There is also minimal future planning, both in terms of financial and infrastructure upgrades. This leaves small water systems particularly vulnerable to neglect.

2. Virginia Small Water Systems Survey

To assess the potential value of the Public Health Performance Appraisal (PHPA) process to Virginia, a survey was performed of all Virginia small water system permit holders. The intent was to collect information regarding each of the areas of the PHPA and to use this data to determine if the weaknesses suggested by the NCR report held true in Virginia. Additionally, it was intended that the assumptions made by the report could be somewhat tested by the actual SDWA violations reported on the survey by the respondents to the survey. In February 1999, an 8 page, 85-question survey was mailed to each of the 3781 small water system permit holders in Virginia. The addresses for these permits were provided by the Virginia Department of Health (VDH) via their website. Each respondent was given between two and three weeks to return the survey in a postage-paid envelope.

A total of 542 surveys were returned. Of these, 499 contained usable data as 43 were returned because the water system was either out of business, had merged with another, or was no longer located at the address used. This represents a return rate of 13.3%. A survey of this kind of organization (small business) typically yields a return rate of between 10-20% (Paxson, 1995). The return rate obtained was thus considered adequate for the purpose of this study. The data was compiled in a computer database and analyzed using SPSS software (SPSS, 1996).

2.1. Response Summary

Survey respondents were given the option of identifying themselves or remaining unanimous. Of the respondents, 258 provided sufficient identification to link their data to a permit number, while the other 242 were not identifiable. The type of water systems these represent breakdown as follows: 126 Community water systems (CWS), 58 Non-transient Non-community water systems (NTNC), and 73 Transient Non-Community water systems (TNCWS). From the permit number, the type and number of violations could be obtained from the EPA. These data were then compared to the answers given to the management questions and statistical analyses were done.

2.2. Variables

To analyze the data, variables that were related were combined together to form one larger variable. The variables created include:

- System knowledge
- Source knowledge
- Future planning
- Financial management
- Preventative maintenance
- Operations
- Emergency preparedness

Each of these is displayed as a histogram later in this study. This allows for the basic strengths and weaknesses to be easily seen. Using these graphs, the need for the PHPA postulations could be evaluated in each of the areas. Additionally, a Chi-squared test was performed on each data set and the SDWA violation data to determine if any relationship exists between the two. This is valuable in terms of prioritizing aspects of the PHPA process. Finally, each individual question used to calculate the combined variable was further examined to determine if there were any notable circumstances that might help explain the relationship and advise the need for PHPAs.

The following sections will summarize the findings of the analysis done in each of these variable areas.

2.3. System Knowledge

2.3.1. Description of the Variable

System knowledge represents a group of questions that assess the respondents' knowledge of their water system's characteristics. The characteristics included in this measurement are:

- Treatment process used by the system
- Depth of wells (if any)
- Age of the water system
- Average gallons pumped per day
- Gallons pumped per day on a peak day
- Knowledge of all federal, state, and other standards
- High and low pressure in the system
- Existence of dead-ends in the system
- Suitability of right-of-ways
- Sufficiency of earth cover over lines
- Materials used for line mains

These factors were weighted in terms of their relative importance and a score between 1 (poor) and 10 (excellent) were derived. A more complete explanation of this calculation is included in Appendix 2 at the end of this report. The outcome of this scaling is depicted in Figure 2.

2.3.2. Interpretation of Findings

From this chart is clear that most of the respondents were very familiar with their system characteristics as defined above. No differences are noted between the different types of water systems, each returning a graph of similar shape. Of the three, non-community transient water systems showed the lowest level of system knowledge. However, with a mean score of 7, it could be concluded that even those respondents have a reasonably good knowledge of their systems.

One possible explanation for this is the potential existence of records for these factors, which could have been referenced when the survey was completed. In fact, the system

knowledge variable is highly related (X^2 = 58.6, p < .0001) to the 'Records kept of existing equipment and supplies' variable (Question 81). This is to say that, those who kept records of their existing equipment and supplies scored higher on the system knowledge scale than those who did not.

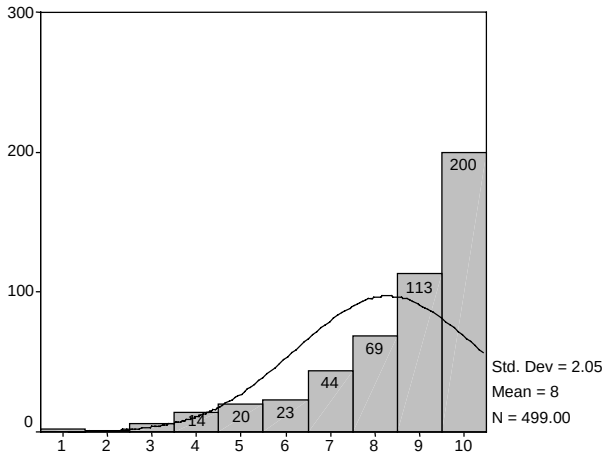

Figure 2. System Knowledge

Thus, the system knowledge variable may in fact be a measurement of record keeping rather than one of an actual, working knowledge of the system characteristics. Given that this is the case, it could be concluded that systems already have sufficient records to display an adequate knowledge of their system characteristics. Measuring the effectiveness of this knowledge in terms of proper water system operation is a much more difficult task and beyond the scope of this study. Indeed, it may only be assessable during onsite visits by Health Inspectors.

2.3.3. Relationship to SDWA violations

There appears to be no relationship between a higher degree of knowledge of the water system's characteristics and the (1) ANYMCL, (2) ANYVIOL, (3) ANYRPT, (4) MCL, and (5) RPTMNTR. Thus, the NCR's suggestion that increased system knowledge will improve system compliance with the SDWA is unsubstantiated. Again, the existence of records can increase an operator's knowledge but may not influence the effective use of this knowledge in operating a water system. It may thus be an ineffective use of time and resources for small water systems to document any further their system characteristics than is already required.

2.3.4. Other Findings of Interest

While, for the most part, Virginia's small water systems scored well on the system knowledge scale, there are a few findings that are important to note.

Fifteen percent of the respondents did not know which treatment process was used in the water system. Transient, non-community systems (16.4%) were more likely to report this

than were community (7.1%) or non-transient non-community water systems (10.7%). Systems with at least one licensed operator (Question 44) reported not knowing their treatment process (Question 1) only 6.9% of the time, while systems with no licensed operators did so 22.0% of the time ($X^2 = 22.2$, $p < .0001$). This would indicate that at least part of the reason that some respondents do not know their treatment type is directly attributable to training.

Similar results were found for the questions on the use of backflow protection devices (Question 38) ($X^2 = 25.0$, $p < .0001$) and "dead ends" in the mains (Question 39) ($X^2 = 38.2$, $p < .0001$). Systems with no licensed operators reported not knowing if they had backflow protection devices 23.8% of the time, while those with licensed operators 10.5% of the time. Systems with no licensed operators reported not knowing if they had "dead-ends" in the mains 12.8% of the time, while those with licensed operators 3.1% of the time. Clearly this provides support for the need of additional and more comprehensive operator certification training for small systems.

2.4. Source Knowledge

2.4.1. Definition of Variable

Source knowledge represents a group of questions that assess the respondent's knowledge of the water supply source characteristics. The characteristics included in this measurement are:

For groundwater sources:

- Influence of surface water supply on the source
- Boundary of the well recharge area

For all sources:

- Awareness of other users of the source and their levels of use
- The knowledge of point and non-point sources of pollution within the recharge area
- If farms exist, the familiarity with farming practices
- The knowledge of planning (zoning, watershed, etc.) efforts within the recharge area
- Availability and details of using alternate sources

These factors were weighted in terms of their relative importance and a score between 1 (poor) and 10 (excellent) were derived. A more complete explanation of this calculation is included in the technical addendum at the end of this report. The outcome of this scaling is depicted in Figure 3.

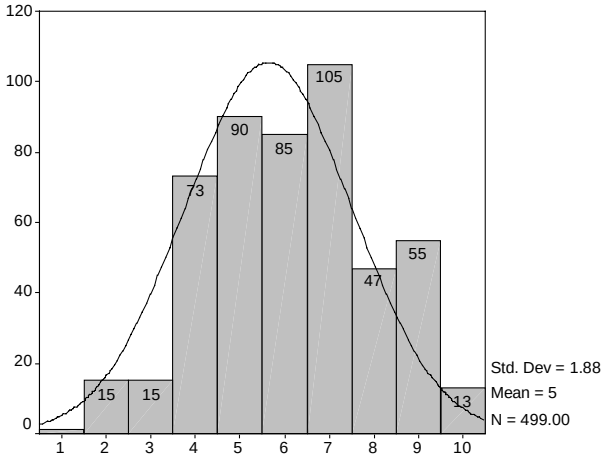

Figure 3. Source Knowledge

2.4.2. Interpretation of Findings

The small water systems were not as familiar with their source water as they were with their own system characteristics. This did not vary between the three types of systems – each having a mean of 5. With the 1996 SWDA amendments emphasizing source water protection as means of improving drinking water quality and reducing the costs of water treatment, active involvement and awareness by drinking water providers in the protection of their direct source seems a logical starting point. As can be seen from the graph above, while many are knowledgeable about their source, there are also many that are not sufficiently aware.

2.4.5. Relationship to SDWA violations

There were no significant relationships between a higher level of water source knowledge and violations of the SDWA, including variables (1) ANYMCL, (2) ANYVIOL, (3) ANYRPT, (4) MCL, and (5) RPTMNTR. This would be expected as source knowledge in the short-term has little effect on the immediate quality of the water. However, over the long-term, it is certainly in the best interest of a water system to be aware of potential threats to their water source.

2.4.6. Other Findings of Interest

Only 17.6% of the respondents knew the boundary of their well recharge area. This may be due to two factors: (1) a lack of technical knowledge, and/or (2) a lack of understanding the technical language (i.e., “recharge area”). If it is the former, it is difficult for water systems to determine other users of their source without knowing the boundaries of the recharge area. In fact, only 23.1% were able to state that they were aware of all others who use the same source as they do. It also makes it difficult for them to determine what human activities might contaminate their water supply. Of the respondents, 28.7% were unable to state whether farms, industrial facilities, wastewater treatment plants, etc., were located in their water source recharge area. The issue of source recharge would seem to be fundamental to any source protection and conservation

efforts. If Virginia is going to improve its source protection efforts, this data suggests that improving individual water systems' awareness of their own water source may be a valuable and effective place to start.

Table 2 shows potential human sources of source water contamination. Two of the primary sources of potential source water contamination are farms and large landscaped areas. Industrial sources are a very small threat, in terms of number, to drinking water supplies. Wastewater treatment plants are only slightly more likely to be located in a drinking water source's recharge area then are large landscaped areas such as golf courses. It should be noted that in spite of this distribution of threats, the only significant relationship between violations of the SDWA and these sources is that of Agricultural Chemical Manufacturers (X^2=5.6, p = .018). Thus, while increased emphasis may be put on non-point sources due to their increased number, these findings tend to support the continued monitoring of point sources that show a greater actual impact on water quality.

Table 2. Potential Sources of Drinking Water Contamination

Farms	167	33.5%
Wastewater treatment facility	51	10.2%
Large landscaped area (ex. Golf course)	48	9.6%
Agricultural chemical manufacturer	11	2.2%
Industrial facility that discharges chemicals	8	1.6%
Don't know	143	28.7%

2.5. Future Planning

2.5.1. Definition of Variable

This variable is a compilation of questions that indicate some consideration, either explicitly or implicitly, for the future needs of both the water system itself or its customers. The factors included in this variable are:

- Awareness of future needs of others who use the same water source
- Knowledge of water system life expectancy
- Projected service population for the water system in 10 years
- Trends in water demand known
- Ability to meet future water demand with current system
- Familiarity with future needs of commercial/industrial customers
- Written plan for increasing capacity
- Water system can be easily upgraded in the event of new technologies or requirements

These factors were each counted as one point. They were combined to get a final score between 1 (poor) and 8 (excellent). The outcome of this scaling is depicted in Figure 4.

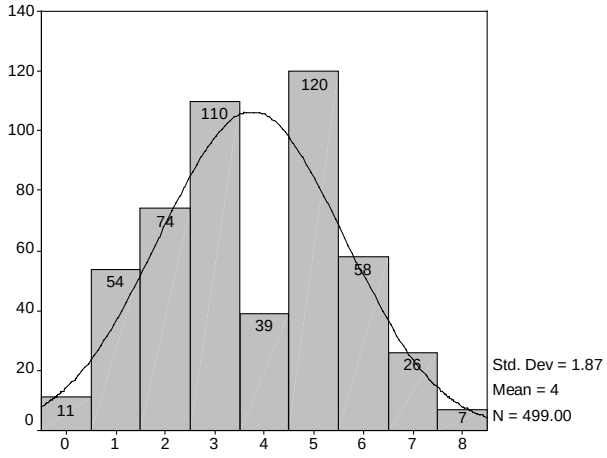

Figure 3. Future Planning

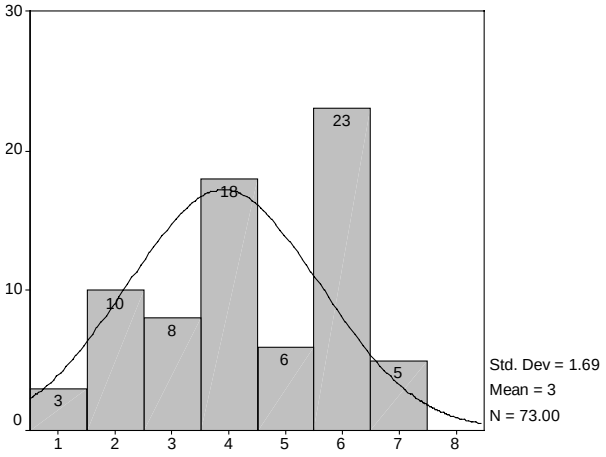

Figure 4. TNCWS Future Planning

2.5.2. Interpretation of Findings

The outcome is a bimodal distribution with the mean in the middle at exactly 4. This indicates that either the water system is doing well at planning or it is not. Both the community water systems and the non-community non-transient systems are about the same shape and have a mean of 4. The transient non-community systems, however, are skewed slightly more towards the left, meaning that they are less likely to plan for the future than the others. Figure 4 shows the difference in the shape of the distribution. This would indicate that significant portions of the water systems are failing to plan for the future. This may become a serious issue given that the average age of the water systems surveyed was 26.6 years and the average life expectancy was 37.3 years.

2.5.3. Relationship to SDWA violations

Future planning does not show any significant relationship with violations of the SDWA. This is predictable as the SDWA focuses on the present situation and is not forward looking.

2.5.4. Other Findings of Interest

Central to the process of future planning is that of being prepared for the replacement of existing facilities. Most of the water systems (85.2%) surveyed were unable to state the life expectancy of their system. Without this knowledge, financial and physical planning for replacement of the facilities is almost impossible. The risk of unanticipated and unplanned-for-failure becomes a possibility. Additionally, some systems may require expansion before they require replacement. Again, large percentages (52.9%) of the systems are unable to project what their service population will be in 10 years. In addition, 27.9% stated that they did not know if they could meet water demand in 10 years with their present system. Preparing for expansion is difficult if these are not known. These findings suggest that a system of mandated future planning, in which water systems look at least ten years into the future and attempt to address potential problems and anticipate needs, is required.

2.6. Financial Management

2.6.1. Definition of Variable

The financial management variable represents the aggregate of several questions, which indicate appropriate financial management practices. The variables included in this measurement are:

- Use of an annual budget
- Monthly budget tracked
- Existing facilities are depreciated in the budget
- Water rates are reviewed regularly
- Schedule in place for capital improvements
- Existence of an operating cash or emergency reserve fund
- Financial level of operation (surplus, loss, break-even)
- Use of a standardized accounting system
- Access to other revenue sources besides customers

These factors were each counted as one point. They were combined to get a total. This was divided by 9 and multiplied by 10 in order to get a final score between 1 (poor) and 10 (excellent). The outcome of this scaling is depicted in Figure 5.

2.6.2. Interpretation of Findings

When looking at all four charts, the findings are quite easily discernable. Community water systems (Figure 6) are typically strong financial managers. This is not surprising because small municipalities typically manage them. Conversely, non-transient non-community systems (Figure 7) are poor managers. This is likely due to the fact that the water systems in these cases are not the primary business activity and are often overlooked in the financial management. Transient non-community systems (Figure 8) tend to score in the middle.

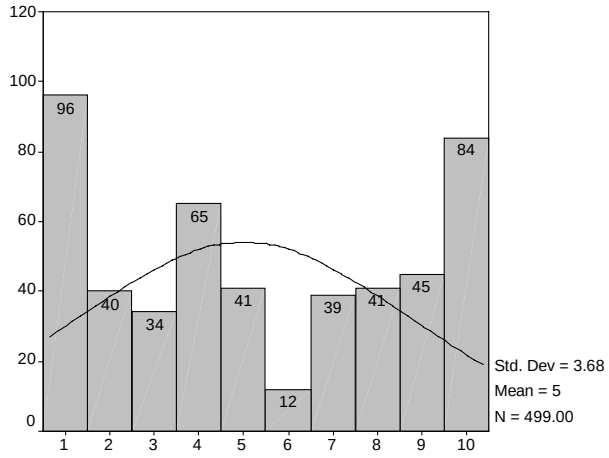

Figure 5. Financial Management

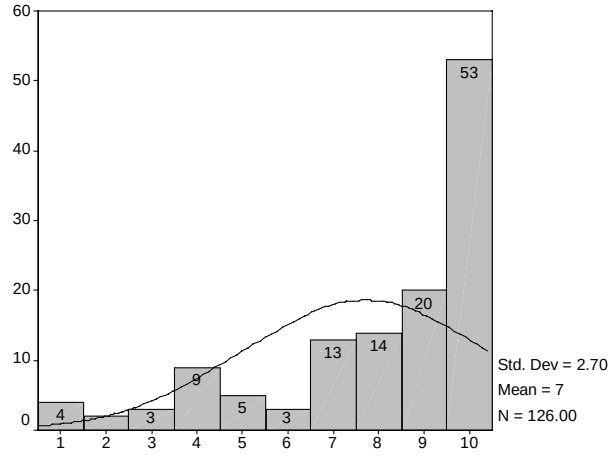

Figure 6. Financial Management CWS

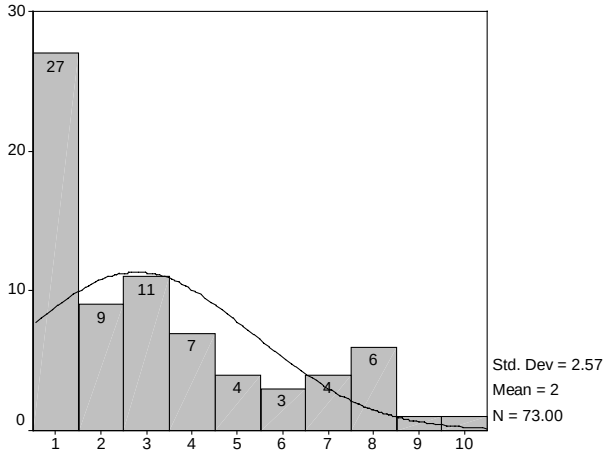

Figure 7. Financial Management NTNCWS

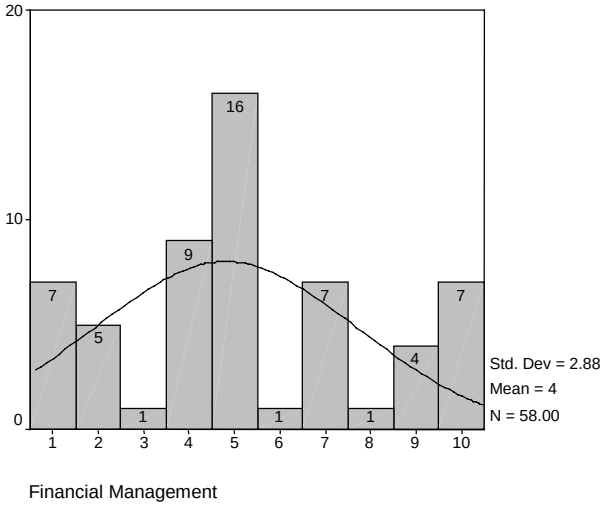

Figure 8. Financial Management TNCWS

2.6.3. Relationship to SDWA violations

A significant relationship exists between having at least one violation of an MCL requirement of the SDWA and the score on the financial management variable (X^2=10.8, p = .028). This relationship is opposite of what was expected however. Increased financial management actually results in greater levels of MCL violations than expected, while decreased financial management has the opposite effect of decreasing the number of MCL violations than expected. The probable explanation for this is that systems that are cited for a violation of the SDWA are likely to increase those practices that will prevent future violations, financial management being one of these. To determine this would require that management practices at the time of the violation be known and

compared with current practices as indicated on this survey. Such a study is beyond the scope of this paper but may provide an interesting future study.

2.6.4. Other Findings of Interest

Budgeting is fundamental to appropriate financial management. Table 3 outlines the use of annual budgets by different types of water systems.

Table 3. Water System Annual Budget

Use budget?	All systems	CWS	NCTWS	NCNTWS
YES	40.8%	70.2%	12.5%	36.8%
NO	59.2%	29.8%	87.5%	63.2%

Only 28.3% of the systems surveyed include depreciation of existing facilities in their budget. Thus, they are not likely setting aside the appropriate funds to upgrade or replace their system when its life cycle is complete. Further, 52.5% confirm that they are not putting aside money for capital improvements, and 48.9% have no operating cash or reserve fund. Fortunately, only 14.3% of the respondents' fall into all three of these categories, the remainder has at least one of these safety nets in place. Interestingly, there exists a significant relationship between a system's use of these budget practices and having had an MCL violation of the SDWA (X^2= 8.8, p= .032). In other words, systems that use these practices are less likely to have violated the SDWA. This would indicate that financial management could be a good measurement of the general management of the water system. Or, it may also suggest that systems with better finances are more capable of maintaining their system in good operating condition.

2.7. Preventative Maintenance

2.7.1. Description of Variable

The preventive maintenance variable represents the group of questions that measure the water systems' efforts to physically maintain their system prior to its needing repair. The variables included in this measurement are:

- Having a preventative maintenance program in place
- Exercising system valves periodically
- Calibrating and testing water meters
- Pumps are periodically and annually inspected
- Tanks are inspected
- Operator training annually
- Receiving outside technical assistance

These factors were each counted as one point. They were totaled to get a final score between 1 (poor) and 8 (excellent). The outcome of this scaling is depicted in Figure 9.

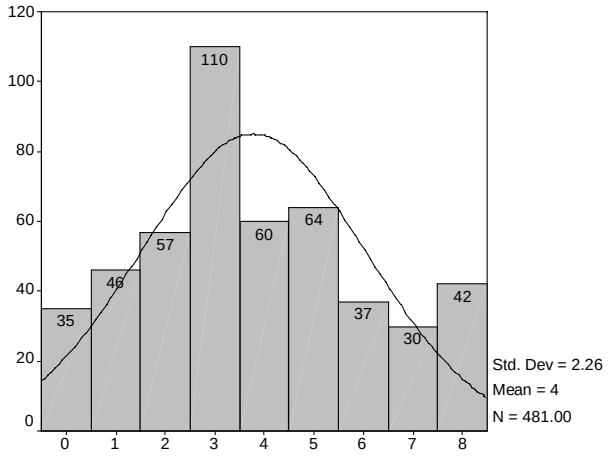

Figure 9. Preventative Maintenance

2.7.2. Interpretation of Findings

Small water systems in Virginia vary in their preventative maintenance practices with the mean score for all systems on this measurement being at 4. This is also consistent with the outcome for each of the different types of water systems, who also scored a mean of 4 each. Of importance to this measurement was the employment of a certified operator. Systems that had certified operators tended to score significantly higher on the preventative maintenance scale (X^2=35.5, p= .0001).

2.7.3. Relationship to SDWA violations

There is a statistically significant relationship between the number of occurrences of MCL violations (X^2=10.3, p= .036) and the occurrence of any MCL violation (X^2=32.3, p= .04) with the preventive maintenance score. Once again, systems with higher scores (those that have better preventative maintenance programs) tend to have a greater occurrence and number of MCL violations than is expected, while those who score poorly tend to have fewer than expected. The probable explanation for this is that preventative maintenance improves following an MCL violation.

2.7.4. Other Findings of Interest

Respondents to the survey indicated that 62.7% did not receive training to update their knowledge at least annually. Additionally, 37.7% stated that they did not receive outside technical assistance. Combining these two variables, 32.2% of the water systems receive neither of these sources of technical information.

2.8. Operations

2.8.1. Description of variable

This variable represents a combination of recommended operational practices. The existence of these practices would presume a better water system. The factors included in this variable are:

- Use of backflow devices in the system
- Presence of "dead-ends" in the mains
- Suitable right-of-ways
- Sufficient earth covering of mains
- Mains made from appropriate materials
- Employment of at least one certified operators
- Documented operations procedures
- Routine leak repair program
- Retention of appropriate records

These factors were weighted in terms of their relative importance and a score between 1 (poor) and 10 (excellent) were derived. A more complete explanation of this calculation is included in the technical addendum at the end of this report. The outcome of this scaling is depicted in Figure 10.

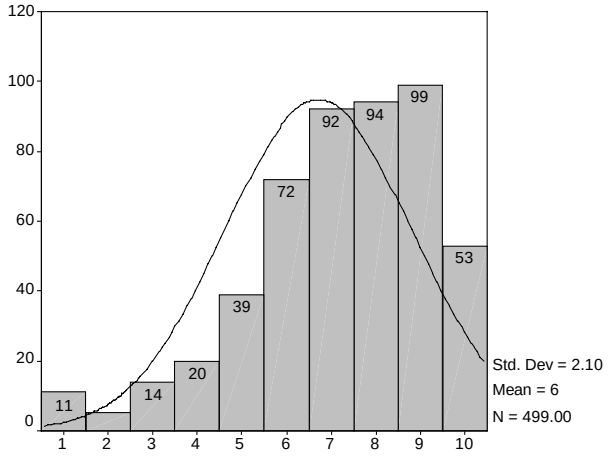

Figure 10. Operations

2.8.2. Interpretation of Findings

The small water systems in Virginia tended to score quite well on the operations index. Community water systems and non-community non-transient systems scored slightly higher than the average system with a mean score of 7. Non-community transient systems scored the lowest with a mean of 5. This variation likely has to do with the association the system has to its owner's business. Non-community transient systems are more likely to be left unattended while the other systems typically are at least a part of the day-to-day operations of the business, if not the actual business itself.

2.8.3. Relationship to SDWA violations

Again, there exists a significant relationship between the systems' having an MCL violation (X^2=10.6, p = .031) and its score on the operations index. This relationship follows the same pattern as mentioned earlier for preventative maintenance and financial management – the higher the system's score on the index, the more likely it is to have an

MCL violation than expected. It is best explained as an improved management response to a previous violation.

2.8.4. Other Findings of Interest

Question #48 asked water systems what documented operations procedures existed for the system. Seven possible procedures were listed and the respondents merely checked off those operations that they actually performed. The results of this are shown in the Table 4.

Table 4. Operations Procedures Used by PWS

System modification	21.6%
New hook ups	26.9%
Construction policy	17.2%
Backflow prevention	54.1%
Cross-connections	44.3%
Customer rights/responsibilities	20.0%
Monitoring requirements	48.3%

For the purpose of analysis, each water system was given a point for each one of these procedures that it had documented for a total of 7 possible points. When this total was compared to SDWA violations, it was found that systems with more documented regulations had significantly less than expected MCL violations (X^2=24.1, p= .001), Reporting and Monitoring violations (X^2=34.5, p= .0001), and any violations (X^2=19.0, p= .008). This would lend support to the suggestion made in the NCR report that all water systems be required to document all regulations they are required to adhere to.

2.9. Emergency Preparedness

2.9.1. Definition of the variable

Emergency preparedness is a combination of variables that indicate the system has made efforts to prepare itself in the event of some sort of system failure. The variables included in this measurement are:

- Use of water tanks as backup
- Size of water tank sufficient to meet one average day's demand
- System has emergency response plan
- Employees are trained for emergency response
- An emergency call-up list exists
- Neighboring utilities have been contacted to pursue emergency interties
- Different operational responses have been tried for different emergency scenarios
- System has emergency power supply
- Records are stored in safe place in event of emergency

Each of these variables was given one point. The total was added up to derive a score between 1 (poor) and 10 (excellent). The outcome of the analysis is shown in Figure 11.

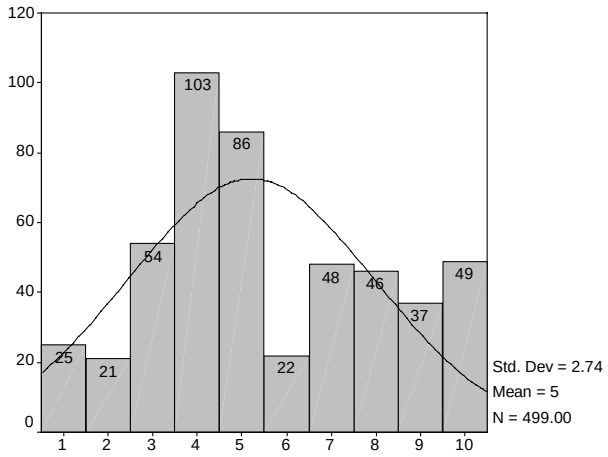

Figure 11. Emergency Preparedness

2.9.2. Interpretation of Findings

While the mean of the entire group was 5, a large number of the respondents are not planning well for emergencies, scoring 5 and below. This is particularly true on the non-community water systems (both transient and non-transient) whose mean score was lower at 4. This is a less serious situation in that these systems do not supply many residences with water.

2.9.3. Relationship to SDWA violations

The emergency preparedness variable showed a significant relationship with both the ANYMCL variable (X^2=9.7, p= .046) and ANYVIOL (X^2=11.9, p= .018). Once again, those who scored high on the index were more likely than expected to have violated a SDWA standard.

2.9.4. Other Findings of Interest

While 87.4% of the systems reported having a storage tank, 44.3% are inadequate to provide even a single day-worth of water demand. Only 48.2% of all water systems surveyed actually have sufficient water storage facilities to provide for one day. Additionally, only 19.8% of all water systems surveyed had an emergency power supply.

Only 33.9% of water systems have any emergency response plan in place. Those who do have this in place are much more likely to have a certified operator (X^2= 15.8, p= .0001), or have received operator training (X^2=39.7, p= .0001). Similarly, for 'being trained in emergency response' (Question 74) (X^2=15.8, p= .0001) and 'having considerably different operational responses for different emergency scenarios' (Question 78) (X^2=33.5, p= .0001). This lends support to the NCR's suggested requirement that all small water systems be required to have at least one certified operator.

2.10. Summary

The Virginia Small Water Systems Survey identified several weaknesses among Virginia's small water systems. Of notable concern were the areas of future planning, financial management by non-community water systems, preventative maintenance, and emergency preparation. It was noted that significant relationships exist between the SDWA violations and financial management, preventative maintenance, operations, and emergency preparation practices. However, this relationship is somewhat counter intuitive in that, systems that show higher levels of these practices actually have violated the SDWA more frequently. It is likely that this finding is the result of improvements in management practices following a violation. In other words, if a system is cited for a violation they respond by improving their management practices in these four areas.

Of additional interest is the role that operator certification plays in water systems. Systems with at least one certified operator reported a higher level of system knowledge, an increased level of preventative maintenance practices, and a use of emergency preparation practices. This lends support to a more comprehensive operator certification requirement that would encompass all small water systems.

Finally, the survey supported the usefulness of record keeping. Systems with better records demonstrated a higher level of system knowledge. Additionally, systems with records pertaining to the regulation requirements were significantly less likely to have violated the SDWA. This would support the NCR's recommendation for increased system record keeping and planning.

3. Public Health Performance Appraisal Implementation

Following a violation of the SDWA, water systems have shown a pattern of improving their management and operating processes. By proactively implementing the Public Health Performance Appraisal system, the VDH will be able to initiate such improvements before a violation occurs and by doing so, presumably, would reduce the number of violations. The following four steps outline a recommended approach for implementing the PHPA process given the outcome of the Virginia Small Water Systems Survey.

Step 1: New Small Water Systems

In addition to the already required financial and construction plans, new small water systems (serving a population of 3300 or less) should be required to provide the following information in the form of a "Water System Plan."

- System management and operations program including preventative maintenance procedures (and documentation), operator certification and opportunity for regular knowledge updates, operation procedures, policies for such issues as cross-connections, dead-ends, materials, leak testing and repair, and record keeping.

- Water system facilities inventory and characteristics including treatment, storage, and supply transportation equipment, map of facilities and connections.

- Information regarding and demonstrating a review of other local plans and issues related to source protection and conservation. These would include local land use plan, watershed plans, zoning ordinances, wellhead protection plans, and the water system plans of adjacent water systems.

- A plan for future expansion, upgrade, or replacement of the system including planned system improvements, projections of future and expected demand, anticipated source water usage, and life expectancy estimates.

- An emergency response plan including a call-up list, emergency sources and interties, storage facilities, emergency power supplies, safe storage of records, and regular testing procedure to avert potential system failure.

- A complete list of federal, state, and local regulations to which the water system must adhere should be compiled as part of the plan. A review of potential problem areas should be included with a list of approaches that will be taken to avoid violations of these regulations.

This plan would be reviewed for its completeness and, if sufficient, approved by the VDH. A checklist of potential review questions is included in Appendix D. Combining the information provided herein with records of sanitary survey results, compliance with water quality standards, and operator certification requirements, would comprise the PHPA. Upon review of these, if deficiencies exist, the VDH would write a letter

outlining the areas of weakness and a permit would not be granted until appropriate consideration and revision of the proposed plan was completed.

Step 2: Water System Plans for Existing Systems

For systems that are already in existence and permitted, a water system plan would not be required until (a) the system decided to expand, (b) it failed to comply with water quality or reporting/monitoring regulations, or (c) the VDH determined that sufficient problems existed that, without improvements, public health could be at risk. An incentive exists for systems that do not want to go through the trouble of creating a plan to be even more careful about meeting all of the regulations.

Step 3: Annual Updates to the Water System Plan

Annually each water system that has created a plan would be required to submit an update to it. This should include an annual financial plan and budget, a summary of further operator training and certification, as well as a review and revision of those items required in the initial water system plan. Again, these revisions would be reviewed by the VDH and approved based on their appropriateness and completeness. During this review, corrections to situations that have posed problems for the water system, resulted in violations of the SDWA, or were noted during sanitary surveys as potential problems, should be particularly looked at to ensure corrective action is taken.

Step 4: Compliance Monitoring

As part of the sanitary survey process, the Water System Plan should be reviewed briefly at each site visit to ensure that efforts are being made to adhere to the outlined plans. In particular, when systems fail to comply with some regulation, part of the process of corrective action could be a review of the plan and an assessment of where either the system had deviated from it or where it needs to be improved. Systems that fail to comply with the Water System Plan requirement would not be authorized to receive permits to expand nor be able to apply for state funds to assist the water system. Where limited resources exist, these reviews could happen intermittently and randomly, such that over a period of several years all systems would be reviewed but that systems would not know when the review would occur.

Summary

The intent of the PHPA system is to (a) provide the VDH with a more broad perspective of the water system, so potential weaknesses can be identified early and addressed before they become a problem, rather than after a violation has occurred, and (b) encourage individual water systems to annually assess their own system management, operations, and financial capabilities. By requiring only new, expanding, and problematic systems to create a water system plan, VDH should be able to justify its requirement as part of its regular procedures without much backlash. Systems that operate without problems would be able to avoid the requirement by merely keeping in compliance with the regulations.

4. Washington State Experience

The idea of Public Health Performance Appraisals (PHPA) is a fairly new one. Several states are beginning to use similar processes as discussed in the previous section. For the purpose of this report the program used by the state of Washington will be reviewed. The information reported here was obtained through a personal interview with Peter Beaton of the Washington Department of Health on August 23, 1999.

Washington operates two separate programs related to Public Health Performance Appraisals. The first is their water system planning program, which has been instituted among community water systems that (a) are new, (b) are expanding, (c) are problematic, or (d) have 1000 connections or more. The second is called the Small Water System Management Program. This program applies to all systems that do not fall into one of the categories listed above. Both are similar in that they require the writing of a water system plan, but the former is much more involved and detailed than the latter.

Response to these programs has been quite favorable. This is primarily because they are required only as part of already acceptable administrative practices such as initial permitting or as part of a regulatory violation. Even revisions of the initial plans, which are not associated with other actions, are well accepted, as the water system owners and operators have acknowledged the value of performing the review. The cost was the only noted negative response, because the Washington State requires plans be submitted by a certified engineer.

In terms of administration, lack of funding has prevented the Department of Health (DOH) from fully monitoring compliance. This is changing, however, with the additional funds available from the EPA as part of the State Revolving Fund program.

No formal study has been done to assess whether the plans result in higher water quality and fewer violations. However, inspectors have reported notable and impressive improvements in the managerial and operational procedures of the systems that have been required to write such a plan due to a violation.

Overall, the DOH continues to promote this program and is in the process of improving and increasing its inclusion of water systems statewide. The DOH is about to print a handbook for small water systems to assist them in their efforts to comply with the Small Water System Management Program. DOH officials also conference with each system as it begins creating its plan to ensure the plan is compiled correctly. *Safe Water from Every Tap* (NRC, 1997) uses the Washington State program as its model.

Further information about this program can be obtained from Peter Beaton at (360)236-3150 or Richard Siffert (360) 236-3146.

5. References

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NRC. 1997. *Safe water from every tap: improving water service to small communities*. (1st ed.). Washington, D.C.: National Academy Press.

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Appendix A. Survey of Virginia Small Water Systems

Section A.Water Quality

1. Which treatment processes are used in this water system?

N=499

Filtration	97	19.4%
Disinfection	204	40.9%
Oxidation	12	2.4%
Coagulation	27	5.4%
Adsorption	0	0.0%
Air stripping	0	0.0%
Don't know	75	15.0%

	CWS N=126		TNCWS N=73		NTNC N=58	
Filtration	27	21.4%	18	24.7%	14	25.0%
Disinfection	58	46.0%	25	34.2%	15	26.8%
Oxidation	6	4.8%	1	1.4%	1	1.8%
Coagulation	15	11.9%	1	1.4%	1	1.8%
Adsorption	0	0.0%	0	0.0%	0	0.0%
Air stripping	0	0.0%	0	0.0%	0	0.0%
Don't know	9	7.1%	12	16.4%	6	10.7%

	ID N=257		NID N=242	
Filtration	59	23.0%	38	15.4%
Disinfection	98	38.1%	106	42.9%
Oxidation	8	3.1%	4	1.6%
Coagulation	17	6.6%	10	4.0%
Adsorption	0	0.0%	0	0.0%
Air stripping	0	0.0%	0	0.0%
Don't know	27	10.5%	48	19.4%

2. When was the most recent sanitary survey performed?

Data not useful, respondents were confused as to what a 'sanitary survey' is.

3. Was the outcome of this sanitary survey positive or negative?

Data not useful, respondents were confused as to what a 'sanitary survey' is.

N=386

Positive	198	51.3%
Negative	186	48.2%
Don't know	2	0.5%

	CWS N=85		NCWS N=62		NTNC N=48	
Positive	54	63.5%	24	38.7%	21	43.8%
Negative	30	35.3%	37	59.7%	27	56.3%
Don't know	1	1.2%	1	1.6%	0	0.0%

	ID=195		NID=191	
Positive	99	50.8%	99	51.8%
Negative	94	48.2%	92	48.2%
Don't know	2	1.0%	0	0.0%

Section B.Source Water

3. What is the water source for this water system?

N=486

Groundwater	446	89.4%
Surface water	24	4.9%
Wholesale	8	1.6%
Other	8	1.6%

	CWS N=124		NCWS N=72		NTNC N=57	
Groundwater	107	86.3%	70	97.2%	56	98.2%
Surface water	10	8.1%	1	1.4%	1	1.8%
Wholesale	6	4.8%	0	0.0%	0	0.0%
Other	1	0.8%	1	1.4%	0	0.0%

	ID N=253		NID N=233	
Groundwater	233	92.1%	213	91.4%
Surface water	12	4.7%	12	5.2%
Wholesale	6	2.4%	2	0.9%
Other	2	0.8%	6	2.6%

Answer questions 5 through 12 only if the source is “Groundwater”. Skip to question 13 on the next page if it is not.

4. Is the water source under the influence of surface water?

N=465

Yes	32	6.9%
No	377	81.1%
Don’t know	56	12.0%

	CWS N=114		TNCWS N=71		NTNC N=57	
Yes	11	9.6%	4	5.6%	1	1.8%
No	93	81.6%	58	81.7%	54	94.7%
Don’t know	10	8.8%	9	12.7%	2	3.5%

	ID N=242		NID N=223	
Yes	16	6.6%	16	7.2%
No	205	84.7%	172	77.1%
Don’t know	21	8.7%	35	15.7%

5a. If the answer to Question 5 is “Yes”, do you meet all the requirements of the Surface Water Treatment Rule?

N=28 (“Yes” to question 5)

Yes	16	57.1%
No	3	10.7%
Don’t know	9	32.1%

	CWS N=9		TNCWS N=4		NTNC N=1	
Yes	6	66.7%	1	25.0%	1	100.0%
No	2	22.2%				
Don’t know	1	11.1%	3	75.0%		

	ID N=14		NID N=14	
Yes	8	57.1%	8	57.1%
No	2	14.3%	1	7.1%
Don't know	4	28.6%	5	35.7%

N=58 (All respondents)

Yes	26	44.8%
No	6	10.3%
Don't know	26	44.8%

	CWS N=15		TNCWS N=87		NTNC N=5	
Yes	8	53.3%	3	37.5%	1	20.0%
No	2	13.3%	2	25.0%		
Don't know	5	33.3%	3	37.5%	4	80.0%

	ID N=28		NID=30	
Yes	12	42.9%	14	46.7%
No	4	14.3%	2	6.7%
Don't know	12	42.9%	14	46.7%

5. How many wells are used for this water system?

0	5	1.1%
1	287	62.8%
2	91	19.9%
3	33	7.2%
4	15	3.3%
5	6	1.3%
6	6	1.3%
8	8	1.8%
9	1	0.2%
12	12	0.9%
17	1	.2%
Total	457	100%

	CWS N=107		TNCWS N=71		NTNC N=57	
0	3	2.8%	1	1.4%	0	0.0%
1	30	28.0%	56	78.9%	38	66.7%
2	35	32.7%	8	11.3%	6	10.5%
3	16	15.0%	3	4.2%	5	8.8%
4	6	5.6%	3	4.2%	2	3.5%
5	4	3.7%	0	0.0%	1	1.8%
6	4	3.7%	0	0.0%	1	1.8%
8	7	6.5%	0	0.0%	1	1.8%
9	1	0.9%	0	0.0%	0	0.0%
12	1	0.9%	0	0.0%	3	5.3%
17	0	0.0%	0	0.0%	1	1.8%
Total	107	100%	457	100%	457	100%

	ID		NID	
0	4	1.7%	1	0.5%
1	124	52.8%	163	73.4%
2	49	20.9%	42	18.9%
3	24	10.2%	9	4.1%
4	9	3.8%	6	2.7%
5	6	2.6%	0	0.0%
6	5	2.1%	1	0.5%
8	8	3.4%	0	0.0%
9	1	0.4%	0	0.0%
12	4	1.7%	0	0.0%
17	1	0.4%	0	0.0%
Total	235	100%	222	100%

6. List the depths of each well used in this water system:

Don't know	77	15.6%
Average Depth	332 ft	

	CWS N=100		TNCWS N=67		NTNC N=55	
Don't know	12	12.0%	10	14.9%	8	14.5%
Average Depth	365 ft		296 ft		397 ft	

	ID N=222		NID N=176	
Don't know	30	13.5%	3	1.7 %
Average Depth	344 ft		284 ft	

7. What is the name of the aquifer from which this water system draws its water?

Don't know	386	89.1%

	CWS N=107		TNCWS N=57		NTNC N=51	
Don't know	92	86.0%	55	96.5%	51	100%

	ID N=200		NID N=191	
Don't know	197	98.5%	189	99.0%

8. Do you know the boundary of your well recharge area?

	N=448	
Yes	79	17.6%
No	369	82.4%

	CWS N=107		TNCWS N=69		NTNC N=56	
Yes	25	23.4%	15	21.7%	13	23.2%
No	82	76.6%	54	78.3%	43	76.8%

	ID N=232		NID=216	
Yes	53	22.8%	26	12.0%
No	179	77.2%	190	88.0%

10. Are the wells located outside the zone of influence of any nearby stream or river?

N=451

Yes	281	62.3%
No	54	12.0%
Don't know	116	25.7%

	CWS N=110		TNCWS N=69		NTNC N=54	
Yes	74	67.3%	34	49.3%	37	68.5%
No	11	10.0%	14	20.3%	8	14.8%
Don't know	25	22.7%	21	30.4%	9	16.7%

	ID N=233		NID=218	
Yes	145	62.2%	136	62.4%
No	33	14.2%	21	9.6%
Don't know	55	23.6%	61	28.0%

11. Were the wells constructed under a permit from the VDH?

N=455

Yes	358	78.7%
No	26	5.7%
Don't know	71	15.6%

	CWS N=109		TNCWS N=70		NTNC N=57	
Yes	97	89.0%	53	75.7%	52	91.2%
No	3	2.8%	4	5.7%	4	7.0%
Don't know	9	8.3%	13	18.6%	1	1.8%

	ID N=236		NID=219	
Yes	202	85.6%	156	71.2%
No	11	4.7%	15	6.8%
Don't know	23	9.7%	48	21.9%

12. Are all wells capped, shafts encased, and casings intact?

N=456

Yes	435	95.4%
No	5	1.1%
Don't know	16	3.5%

	CWS N=109		TNCWS N=70		NTNC N=57	
Yes	107	98.2%	65	92.9%	56	98.2%
No	2	1.8%	2	2.9%	0	0.0%
Don't know	0	0.0%	3	4.3%	1	1.8%

	ID N=236		NID=220	
Yes	228	96.6%	207	94.1%
No	4	1.7%	1	0.5%
Don't know	4	1.7%	12	5.5%

13. What is the water source capacity per day?

N=478

Don't know	238	47.7%

	CWS N=117		TNCWS N=69		NTNC N=58	
Don't know	41	35.0%	37	53.6%	32	55.2%

	ID N=244		NID N=229	
Don't know	110	45.1%	128	55.9%

Other data not useful, respondents reported their system capacity rather than the source capacity in many cases.

14. Are you aware of all other water systems that use the same source?

	N=476	
Yes	110	23.1%
No	366	76.9%

	CWS N=117		TNCWS N=68		NTNC N=58	
Yes	21	17.9%	17	25.0%	12	20.7%
No	96	82.1%	51	75.0%	46	79.3%

	ID N=243		ID N=233	
Yes	50	20.6%	60	25.8%
No	193	79.4%	173	74.2%

14a. If the answer to Question 14 is "Yes", do you know the levels of water that they use?

	N=99 (Answered "Yes" #14)	
Yes	34	34.3%
No	65	65.7%

	CWS N=17		TNCWS N=		NTNC N=10	
Yes	7	41.2%	2	100%	3	30.0%
No	10	58.8%	0	0.0%	7	70.0%

	ID N=44		ID N=55	
Yes	12	27.3%	22	40.0%
No	32	72.7%	33	60.0%

	N=142 (all respondents)	
Yes	34	23.9%
No	108	76.1%

	CWS N=33		TNCWS N=20		NTNC N=20	
Yes	7	21.2%	2	10.0%	3	15.0%
No	26	78.8%	18	90.0%	17	85.0%

	ID N=73		ID N=69	
Yes	12	2.4%	22	31.9%
No	61	83.6%	47	68.1%

14b. If the answer to Question 14 is "Yes", are you aware of any future changes anticipated in their water use?

N=85 (Answered "Yes" #14)

Yes	27	31.8%
No	58	68.2%

	CWS N=14		TNCWS N=2		NTNC N=11	
Yes	4	28.6%	2	100%	7	63.6%
No	10	71.4%	0	0.0%	4	36.4%

	ID N=39		ID N=46	
Yes	14	35.9%	13	28.3%
No	25	64.1%	33	71.7%

(All respondents)
N=121

Yes	30	24.8%
No	91	75.2%

	CWS N=26		TNCWS N=20		NTNC N=20	
Yes	5	19.2%	3	15.0%	3	15.0%
No	21	80.8%	17	85.0%	17	85.0%

	ID N=62		ID N=59	
Yes	16	25.8%	14	23.7%
No	46	74.2%	45	76.3%

15. Do any of the following exist in the water source recharge area (check all that apply):

Wastewater treatment facility	51	10.2%
Agricultural chemical manufacturer	11	2.2%
Large landscaped area (ex. Golf course)	48	9.6%
Industrial facility that discharges chemicals	8	1.6%
Farms	167	33.5%
Don't know	143	28.7%

	CWS		TNCWS		NTNC	
Wastewater treatment facility	12	9.5%	6	8.2%	8	14.3%
Agricultural chemical manufacturer	2	1.6%	4	5.5%	3	5.4%
Large landscaped area (ex. Golf course)	18	14.3%	6	8.2%	5	8.9%
Industrial facility that discharges chemicals	1	0.8%	3	4.1%	0	0.0%
Farms	43	34.1%	23	31.5%	23	41.1%
Don't know	27	21.4%	25	34.2%	11	19.6%

	ID N=257		NID N=242	
Wastewater treatment facility	26	10.1%	25	10.3%
Agricultural chemical manufacturer	9	3.5%	2	0.8%
Large landscaped area (ex. Golf course)	30	11.7%	18	7.4%
Industrial facility that discharges chemicals	4	1.6%	4	1.7%
Farms	89	34.6%	78	32.2%
Don't know	63	24.5%	80	33.1%

16. If there are farms located in your recharge area, are you familiar with the (check all that apply):

Only respondents who replied “Farms” in #15

Crops	91	54.5%
Cultivation practices	68	40.7%
Associated chemicals	37	22.2%
Application schedules	27	16.2%
Not familiar with any farm practices	73	43.7%
No farms exist in the recharge are	5	3.0%

	CWS N=43		TNCWS N=23		NTNC	N=23
Crops	20	46.5%	14	60.9%	12	52.2%
Cultivation practices	16	37.2%	12	52.2%	11	47.8%
Associated chemicals	9	20.9%	5	21.7%	5	21.7%
Application schedules	6	14.0%	5	21.7%	4	17.4%
Not familiar with any farm practices	20	46.5%	9	39.1%	11	47.8%
No farms exist in the recharge are	1	2.3%	1	4.3%	0	0.0%

	ID N=87		NID N=76	
Crops	46	52.9%	45	59.2%
Cultivation practices	39	44.8%	29	38.2%
Associated chemicals	19	21.8%	18	23.7%
Application schedules	15	17.2%	12	15.8%
Not familiar with any farm practices	47	54.0%	33	43.4%
No farms exist in the recharge are	2	2.3%	3	3.9%

All respondents

Crops	105	21.0%
Cultivation practices	76	15.2%
Associated chemicals	45	9.0%
Application schedules	30	6.0%
Not familiar with any farm practices	146	29.3%
No farms exist in the recharge are	145	29.1%

	CWS N=102		TNCWS N=49		NTNC N=53	
Crops	23	22.5%	16	32.7%	12	22.6%
Cultivation practices	17	16.7%	13	26.5%	11	20.8%
Associated chemicals	9	8.8%	8	16.3%	5	9.4%
Application schedules	6	5.9%	7	14.3%	4	7.5%
Not familiar with any farm practices	43	42.2%	20	40.8%	17	32.1%
No farms exist in the recharge are	35	34.3%	19	38.8%	21	39.6%

	ID N=204		NID N=184	
Crops	51	25.0%	54	29.3%
Cultivation practices	41	20.1%	35	19.0%
Associated chemicals	22	10.8%	23	12.5%
Application schedules	17	8.3%	13	7.1%
Not familiar with any farm practices	80	39.2%	66	35.9%
No farms exist in the recharge are	75	36.8%	70	38.0%

17. Are you familiar with the following plans for your water source recharge area (check all that apply):

Watershed plan	43	8.6%
Wellhead protection plan	93	18.6%
Land Use plans	115	23.0%
Zoning ordinances	113	22.6%
Comprehensive plan	68	13.6%
Don't know	264	52.9%

	CWS N=107		TNCWS N=64		NTNC N=52	
Watershed plan	14	13.1%	6	9.4%	3	5.8%
Wellhead protection plan	30	28.0%	17	26.6%	16	30.8%
Land Use plans	40	37.4%	13	20.3%	16	30.8%
Zoning ordinances	40	37.4%	12	18.8%	16	30.8%
Comprehensive plan	21	19.6%	8	12.5%	6	11.5%
Don't know	46	43.0%	39	60.9%	28	53.8%

	ID N=257		NID N=242	
Watershed plan	23	8.9%	20	8.3%
Wellhead protection plan	63	24.5%	30	12.4%
Land Use plans	69	26.8%	46	19.0%
Zoning ordinances	68	26.5%	45	18.6%
Comprehensive plan	35	13.6%	33	13.6%
Don't know	113	44.0%	151	62.4%

18. Does the water system have a Water Source Conservation plan?

	N=485	
Yes	60	12.4%
No	256	54.8%
Don't know	159	32.8%

	CWS N=123		TNCWS N=428		NTNC N=58	
Yes	19	15.4%	10	14.1%	10	17.2%
No	73	59.3%	28	39.4%	31	53.4%
Don't know	31	25.2%	33	46.5%	17	29.3%

	ID N=252		NID N=233	
Yes	39	15.5%	21	9.0%
No	132	52.4%	134	57.5%
Don't know	81	32.1%	78	33.5%

19. Are there alternative water sources available?

	N=491	
Yes	132	26.9%
No	314	64.0%
Don't know	45	9.2%

	CWS N=124		TNCWS N=71		NTNC N=58	
Yes	39	31.5%	19	26.8%	10	17.2%
No	71	57.3%	44	62.0%	44	75.9%
Don't know	14	11.3%	8	11.3%	4	6.9%

	ID N=253		NID N=238	
Yes	68	26.9%	64	26.9%
No	159	62.8%	155	65.1%
Don't know	26	10.3%	19	8.0%

19a. If the answer to Question 19 is "Yes", do you know the details of using the alternative source?

N=126 (Answered "Yes" to 19)		
Yes	95	75.4%
No	31	24.6%

	CWS N=38		TNCWS N=13		NTNC N=6	
Yes	32	84.2%	9	69.2%	3	50.0%
No	6	15.8%	4	30.8%	3	50.0%

	ID N=63		NID=63	
Yes	47	74.6%	48	76.2%
No	16	25.4%	15	23.8%

N=147 (all respondents)		
Yes	96	65.3%
No	51	34.7%

	CWS N=41		TNCWS N=28		NTNC N=10	
Yes	33	80.5%	12	42.9%	3	30.0%
No	8	19.5%	16	57.1%	7	70.0%

	ID N=79		ID N=68	
Yes	48	60.8%	48	70.6%
No	31	39.2%	20	29.4%

Section C.Water System Characteristics

20. What is the age of the water system?

	N=489	
Don't know	69	14.1%
Average Age	26.5 yrs	

	CWS N=123		TNCWS N=71		NTNC N=58	
Don't know	14	11.4%	13	18.3%	7	12.1%
Average Age	28.5		22.2		25.1	

	ID N=252		NID N=237	
Don't know	34	13.5%	35	14.8%
Average Age	27.8		25.1	

21. What is the water systems life expectancy?

N=459

Don't know	391	85.2%
Average Age	37.3 yrs	

	CWS N=117		TNCWS N=66		NTNC N=46	
Don't know	98	83.8%	59	89.4%	35	76.1%
Average Age	8.5		28.6		29.5	

	ID N=229		NID N=230	
Don't know	192	83.8%	199	86.5%
Average Age	35.8		39.0	

22. What is the service population of your water system?

N=457

Don't know	88	19.3%
Mean Population	481	N=330*
Median Population	200	N=330*
Sum population of study	162165	N=330*

	CWS N=123		TNCWS N=61		NTNC N=53	
Don't know	14	11.4%	27	44.3%	4	7.5%
Mean Population	677	N=109	491	N=34	591	N=49
Median Population	200	N=109	99	N=34	305	N=49
Sum population of study	73875	N=109	16709	N=34	28974	N=49

	ID N=237		NID N=220	
Don't know	45	19.0%	43	19.5%
Mean Population	620	N=192*	324	N=177*
Median Population	250	N=192*	175	N=177*
Sum population of study	108567	N=192*	50299	N=177*

* Population reporting was difficult for non-community waterworks because of the transient population. Some reported annual figures (some as high as 700,000), other's only residents (as low as 1 or 2). To correct for this the mean and median population figures include on those reporting populations between 25 and 3300, the designated small systems range.

23. What is the projected service population for the water system in 10 years?

N=463

Don't know	245	52.9%
Mean Population	450	N=190*
Median Population	222	N=190*

	CWS N=121		TNCWS N=63		NTNC N=55	
Don't know	61	50.4%	27	44.3%	31	56.4%
Mean Population	818	N=60	687	N=18	758	N=24
Median Population	195	N=60	125	N=18	525	N=24

	ID N=239		NID N=224	
Don't know	137	57.3%	108	48.2%
Mean Population	565	N=90*	345	N=100*
Median Population	235	N=90*	213	N=100*

* See note in #22.

24. How many service connections are there in the water system?

		Mean
Residential	N=252	171
Multi-family	N=47	23.5
Commercial	N=267	10.6
Industrial	N=0	0

	CWS	Mean	TNCWS	Mean	NTNC	Mean
Residential	N=111	293.6	N=31	7.6	N=11	221
Multi-family	N=13	16.5	N=8	3.8	N=1	7
Commercial	N=53	31.8	N=49	6.0	N=33	2.4
Industrial	N=126	0	N=0	0	N=0	

	ID	Mean	NID	Mean
Residential	N=153	230	N=99	80.9
Multi-family	N=22	11.4	N=25	34.2
Commercial	N=135	15.3	N=132	5.9
Industrial	N=0	0	N=0	0

25. How many gallons per day (Gpd) on average do you pump?

	N=460	
Don't know	139	30.2%
Mean Gallons per day	76023 gpd	
Median Gallons per day	3500 gpd	
Minimum Gallons per day	4 gpd	
Maximum Gallons per day	6000000 gpd	

	CWS N=111		TNCWS N=69		NTNC N=53	
Don't know	13	11.7%	38	55.1%	9	17.0%
Mean Gallons per day	96739.3gpd		2314.6 gpd		gpd	
Median Gallons per day	41500 gpd		600 gpd		gpd	
Minimum Gallons per day	17 gpd		100 gpd		gpd	
Maximum Gallons per day	1070000 gpd		20600 gpd		gpd	

	ID N=233		NID N=227	
Don't know	139	30.2%	139	30.2%
Mean Gallons per day	66066 gpd		84542 gpd	
Median Gallons per day	2500 gpd		8000 gpd	
Minimum Gallons per day	4 gpd		17 gpd	
Maximum Gallons per day	6000000 gpd		2000000 gpd	

26. How many gallons per day (Gpd) on a peak day do you pump?

N=461

Don't know	199	43.2%
Mean Gallons per day	199015 gpd	
Median Gallons per day	6000 gpd	
Minimum Gallons per day	7.1 gpd	
Maximum Gallons per day	25000000 gpd	

	CWS N=121		TNCWS N=68		NTNC N=49	
Don't know	40	33.1%	35	51.5%	14	28.6%
Mean Gallons per day	146971 gpd		6276.8 gpd		115 309 gpd	
Median Gallons per day	75000 gpd		1200 gpd		2623 gpd	
Minimum Gallons per day	20 gpd		200 gpd		150 gpd	
Maximum Gallons per day	1200000 gpd		43200 gpd		2000000 gpd	

	ID N=238		NID N=223	
Don't know	110	49.3%	89	37.4%
Mean Gallons per day	101941 gpd		272634gpd	
Median Gallons per day	4500 gpd		11000 gpd	
Minimum Gallons per day	7.1 gpd		20 gpd	
Maximum Gallons per day	6000000 gpd		25000000gpd	

27. What is your instantaneous peak day demand?
Data is useless because respondents were confused by the term 'instantaneous peak day demand'.

28. The water demand for this water system is:

N=491

Growing	149	30.3%
Declining	19	3.9%
Remaining stable	313	63.7%
Don't know	10	2.0%

	CWS N=125		TNCWS N=71		NTNC N=	
Growing	60	48.0%	22	31.0%	149	30.3%
Declining	2	1.6%	1	1.4%	19	3.9%
Remaining stable	63	50.4%	46	64.8%	313	63.7%
Don't know	0	0.0%	2	2.8%	10	2.0%

	ID N=254		NID N=237	
Growing	98	38.6%	51	21.5%
Declining	6	2.4%	13	5.5%
Remaining stable	148	58.3%	165	69.6%
Don't know	2	0.8%	8	3.4%

29. Are you familiar with the future (10 year) needs of your commercial and/or industrial customers?

N=438

Yes	194	44.3%
No	244	55.7%

	CWS N=112		TNCWS N=62		NTNC N=54	
Yes	53	47.3%	27	43.5%	23	42.6%
No	59	52.7%	35	56.5%	31	57.4%

	ID N= 228		ID N=210	
Yes	103	45.2%	91	43.3%
No	125	54.8%	119	56.7%

30. Can you meet future (10 year) water demand needs with your current system?

N=480

Yes	299	62.3%
No	47	9.8%
Don't know	134	27.9%

	CWS N=124		TNCWS N=69		NTNC N=54	
Yes	78	62.9%	40	58.0%	27	50.9%
No	16	12.9%	7	10.1%	8	15.1%
Don't know	30	24.2%	22	31.9%	18	34.0%

	ID N=246		NID N=234	
Yes	145	58.9%	154	65.8%
No	31	12.6%	16	6.8%
Don't know	70	28.5%	64	27.4%

31. Do you have a written plan for increasing capacity?

N=480

Yes	65	13.5%
No	387	80.6%
Don't know	28	5.8%

	CWS N=122		TNCWS N=68		NTNC N=54	
Yes	21	17.2%	8	11.8%	9	16.7%
No	98	80.3%	55	80.9%	40	74.1%
Don't know	3	2.5%	5	7.4%	5	9.3%

	ID N=244		NID N=236	
Yes	378	15.6%	27	11.4%
No	193	79.1%	194	82.2%
Don't know	13	5.3%	15	6.4%

32. Do you have a list of all federal state and other standards your system must meet?
N=482

Yes	347	72.0%
No	99	20.5%
Don't know	36	7.5%

	CWS N=123		TNCWS N=69		NTNC N=57	
Yes	109	88.6%	33	47.8%	50	87.7%
No	9	7.3%	28	40.6%	5	8.8%
Don't know	5	4.1%	8	11.6%	2	3.5%

	ID N=249		NID N=233	
Yes	192	77.1%	155	66.5%

No	42	16.9%	57	24.5%
Don't know	15	6.0%	21	9.0%

33. Is the water supply source metered?

N=492

Yes	352	71.5%
No	137	27.8%
Don't know	3	0.6%

	CWS N=125		TNCWS N=71		NTNC N=57	
Yes	116	92.8%	28	39.4%	51	89.5%
No	7	5.6%	43	60.6%	6	10.5%
Don't know	2	1.6%	0	0.0%	0	0.0%

	ID N=253		NID N=239	
Yes	195	77.1%	157	65.7%
No	56	22.1%	81	33.9%
Don't know	2	0.8%	1	0.4%

34. Are all water system customers metered?

N=433

Yes	189	43.6%
No	224	51.7%
Don't know	19	4.4%

	CWS N=124		TNCWS N=58		NTNC N=47	
Yes	84	67.7%	7	12.1%	25	53.2%
No	39	31.5%	45	77.6%	18	38.3%
Don't know	1	0.8%	5	8.6%	4	8.5%

	ID N=229		NID N=204	
Yes	116	50.7%	73	35.8%
No	102	44.5%	122	59.8%
Don't know	10	4.4%	9	4.4%

35. At what frequency do leaks occur in the water system?

N=472

Daily	7	1.5%
Weekly	13	2.8%
Monthly	42	8.9%
Annually	99	21.0%
Less often than annually	280	59.3%
Don't know	31	6.6%

	CWS N=113		TNCWS N=70		NTNC N=58	
Daily	1	0.9%	2	2.9%	1	1.7%
Weekly	7	6.2%	2	2.9%	0	0.0%
Monthly	17	15.0%	3	4.3%	1	1.7%
Annually	36	31.9%	15	21.4%	5	8.6%
Less often than annually	49	43.4%	44	62.9%	48	82.8%

Don't know	3	2.7%	4	5.7%	3	5.2%

	ID N=241		NID N=231	
Daily	4	1.7%	3	1.3%
Weekly	9	3.7%	4	1.7%
Monthly	21	8.7%	21	9.1%
Annually	56	23.2%	43	18.6%
Less often than annually	141	58.5%	139	60.2%
Don't know	10	4.1%	21	9.1%

36. What percent of the total water (from source to customer) is unaccounted for?

	N=456	
Percent of total water	52.0%	1.0%
Don't know	256	56.1%

	CWS N=119		TNCWS N=66		NTNC N=55	
Percent of total water (mean)	60.2%		17.2%		9.3%	
Don't know	55	46.2%	41	62.1%	36	65.5%

	ID N=240		NID N=216	
Percent of total water	79.0%	N=108	20.2%	
Don't know	132	55.0%	124	57.4%

37. What is the highest and lowest pressure in the system?

	N=476	
Highest psi	87 mean	60 median
Lowest psi	37 mean	39 median
Don't know	123	25.8%

	CWS N=123		TNCWS N=73		NTNC N=58	
Highest psi	88 mean	75 median	70 mean	58 median	62 mean	60 median
Lowest psi	38 mean	35 median	41 mean	30 median	39 mean	40 median
Don't know	17	13.8%	24	32.9%	8	13.8%

	ID N=209		NID N=216	
Highest psi	77 mean	60 median	99 mean	60 median
Lowest psi	39 mean	40 median	35 mean	35 median
Don't know	49	23.4%	74	34.3%

38. Are backflow protection devices used in the water system?

	N=486	
Yes	418	86.0
No	28	5.8
Don't know	40	8.2

	CWS N=125		TNCWS N=71		NTNC N=58	
Yes	118	94.4%	51	71.8%	56	96.6%
No	5	4.0%	7	9.9%	2	3.4%
Don't know	2	1.6%	13	18.3%	0	0.0%

	ID N=254		NID N=232	
Yes	225	88.6%	193	83.2%
No	14	5.5%	14	6.0%
Don't know	15	5.9%	25	10.8%

39. Are there any “dead ends” in the mains?
N=472

Yes	193	40.9%
No	197	41.7%
Don’t know	82	17.4%

	CWS N=123		TNCWS N=70		NTNC N=58	
Yes	89	72.4%	14	20.0%	19	32.8%
No	28	22.8%	38	54.3%	32	55.2%
Don’t know	6	4.9%	18	25.7%	7	12.1%

	ID N=251		NID N=221	
Yes	122	48.6%	71	32.1%
No	98	39.0%	99	44.8%
Don’t know	31	12.4%	51	23.1%

40. Do you have suitable right-of-way easements for expansion, maintenance, and replacement for all mains?

N=457

Yes	375	82.1%
No	35	7.7%
Don’t know	47	10.3%

	CWS N=125		TNCWS N=65		NTNC N=54	
Yes	105	84.0%	50	76.9%	46	85.2%
No	13	10.4%	4	6.2%	2	3.7%
Don’t know	7	5.6%	11	16.9%	6	11.1%

	ID N=244		NID N=213	
Yes	201	82.4%	174	81.7%
No	19	7.8%	16	7.5%
Don’t know	24	9.8%	23	10.8%

41. Are all mains covered with sufficient earth to protect them from frost and heavy load damage?

N=475

Yes	441	92.8%
No	20	4.2%
Don’t know	14	2.9%

	CWS N=125		TNCWS N=68		NTNC N=	
Yes	121	96.8%	58	85.3%	57	98.3%
No	2	1.6%	3	13.2%	1	1.7%
Don’t know	2	1.6%	9	1.5%	0	0.0%

	ID N=251		NID N=224	
Yes	236	94.0%	205	91.5%
No	12	4.8%	8	3.6%
Don’t know	3	1.2%	11	4.9%

42. Are mains made from materials resistant to corrosion, electrolysis, and deterioration?

N=466

Yes	355	76.2%
No	43	9.2%
Don't know	68	14.6%

	CWS N=123		TNCWS N=65		NTNC N=57	
Yes	102	82.9%	53	81.5%	41	71.9%
No	11	8.9%	63	4.6%	6	10.5%
Don't know	10	8.1%	9	13.8%	10	17.5%

	ID N=245		NID N=221	
Yes	196	80.0%	159	71.9%
No	20	8.2%	23	10.4%
Don't know	29	11.8%	39	17.6%

43. Does the water system use storage tanks?

N=475

Yes	415	87.4%
No	60	12.6%

	CWS N=125		TNCWS N=69		NTNC N=54	
Yes	123	98.4%	56	81.2%	50	92.6%
No	2	1.6%	13	18.8%	4	7.4%

	ID N=248		NID N=227	
Yes	229	92.3%	186	81.9%
No	19	7.7%	41	18.1%

43a. If the answer to Question 43 is "Yes", what volumes are they?

N = 355 (only those "Yes" to 43)

Gallons of storage	152195 mean	6000 median

	CWS N=105		TNCWS N=53		NTNC N=47	
Gallons of storage	299474 mean	64000 median	9284 mean	1500 median	149254 mean	3400 median
Don't know	2	1.9%	4	7.5 %	9	19.1 %

	ID N=248		NID N=227	
Gallons of storage	194592 mean	14500 median	103374 mean	4000 median

N =479 (All respondents)

Gallons of storage	151342 mean	6000 median
Don't know	37	8.0%

	CWS N=105		TNCWS N=53		NTNC N=	
Gallons of storage	299474 mean	64000 median	9284 mean	1500 median	149254 mean	3400 median
Don't know	2	1.9%	4	7.5 %	9	19.1 %

	ID N=206		NID N=188	
Gallons of storage	194592 mean	14500 median	102137 mean	3500 median
Don't know	16	7.8%	21	11.2%

43b. If the answer to Question 43 is “Yes”, are the tanks kept inside a heated building?

N= (Answered “Yes” to 43)

Yes	148	36.3%
No	260	63.7%

	CWS N=121		TNCWS N=55		NTNC N=50	
Yes	15	12.4%	28	50.9%	33	66.0%
No	106	87.6%	27	49.1%	17	34.0%

	ID N=226		NID N=182	
Yes	76	33.6%	72	39.6%
No	150	66.4%	110	60.4%

N=419 (All respondents)

Yes	153	36.5
No	266	63.5

	CWS N=121		TNCWS N=56		NTNC N=53	
Yes	15	12.4%	28	50.0%	33	62.3%
No	106	87.6%	28	50.0%	20	37.7%

	ID N=230		NID N=189	
Yes	76	33.0%	77	40.7%
No	154	67.0%	112	59.3%

43c. If the answer to Question 43 is “Yes”, have the tanks been inspected in the last 3 years?

N= (Answered “Yes” to 43)

Yes	307	82.5%
No	43	11.6%
Don’t know	21	5.6%

	CWS N=112		TNCWS N=48		NTNC N=49	
Yes	98	87.5%	40	83.3%	41	83.7%
No	11	9.8%	4	8.3%	3	6.1%
Don’t know	3	2.7%	4	8.3%	5	10.2%

	ID N=209		NID N=162	
Yes	179	85.6%	128	78.7%
No	18	8.6%	25	15.5%
Don’t know	12	5.7%	9	5.7%

N=381 (All respondents)

Yes	312	81.8%
No	46	12.1%
Don’t know	23	6.1%

	CWS N=112		TNCWS N=49		NTNC N=52	
Yes	98	87.5%	40	81.6%	41	78.8%
No	11	9.8%	4	8.2%	6	11.5%
Don’t know	3	2.7%	5	10.2%	5	9.6%

	ID N=213		NID N=168	
Yes	179	84.0%	133	78.9%
No	21	9.9%	25	15.0%
Don't know	13	6.1%	10	6.1%

Section D: Management, Operations and Maintenance

44. How many certified operators are employed by the water system?

N=424

# of certified operators	1.1 mean	1.0 median
Percent w/ no certified operators	193	38.7

	CWS N=122		TNCWS N=54		NTNC N=53	
# of certified operators	1.7 mean	1.0 median	0.7 mean	0 median	0.9 mean	0.0 median
# w/ No certified operators	30	24.6%	32	59.3%	29	54.7%

# of certified operators	1.1 mean	1.0 median
Percent w/ no certified operators	193	38.7

45. Do all operators receive training at least annually to update their knowledge?

N=394

Yes	147	37.3
No	247	62.7

	CWS N=114		TNCWS N=46		NTNC N=48	
Yes	52	45.6%	9	19.6%	20	41.7%
No	62	54.4%	37	80.4%	28	58.3%

	ID N=208		NID N=186	
Yes	81	38.9%	66	35.5%
No	127	61.1%	120	64.5%

46. In projecting the future demand have you appraised the future staff needs as well?

N=403

Yes	212	52.6
No	143	35.5
Don't know	48	11.9

	CWS N=117		TNCWS N=47		NTNC N=49	
Yes	82	70.1%	14	29.8%	31	63.3%
No	33	28.2%	20	42.6%	12	24.5%
Don't know	2	1.7%	13	27.7%	6	12.2%

	ID N=213		NID N=190	
Yes	127	59.6%	85	44.7%
No	65	30.5%	78	41.1%
Don't know	21	9.9%	27	14.2%

47. Does the water system staff receive regular outside technical assistance?

N=408

Yes	254	62.3
No	154	37.7

	CWS N=118		TNCWS N=49		NTNC N=48	
Yes	88	74.6%	22	44.9%	42	87.5%
No	33	25.4%	27	55.1%	6	12.5%

	ID N=215		NID N=190	
Yes	152	70.7%	102	52.8%
No	63	29.3%	91	47.2%

48. Do documented operations procedures exist for the following (check those that apply):

	N=499	
System modification	108	21.6%
New hook ups	134	26.9%
Construction policy	86	17.2%
Backflow prevention	270	54.1%
Cross-connections	221	44.3%
Customer rights/responsibilities	100	20.0%
Monitoring requirements	241	48.3%

	CWS N=126		TNCWS N=73		NTNC N=58	
System modification	45	35.7%	8	11.0%	45	80.4%
New hook ups	69	54.8%	4	5.5%	23	41.1%
Construction policy	29	23.0%	8	11.0%	11	19.6%
Backflow prevention	93	73.8%	16	21.9%	50	89.3%
Cross-connections	80	63.5%	7	9.6%	41	73.2%
Customer rights/responsibilities	46	36.5%	5	6.8%	9	16.1%
Monitoring requirements	78	61.9%	21	28.8%	17	30.4%

	ID N=257		NID N=242	
System modification	70	27.2%	38	15.7%
New hook ups	96	37.4%	38	15.7%
Construction policy	48	18.7%	38	15.7%
Backflow prevention	159	61.9%	111	45.9%
Cross-connections	128	49.8%	93	38.4%
Customer rights/responsibilities	60	23.3%	41	16.9%
Monitoring requirements	144	56.0%	98	40.5%

49. Does the water system have a preventative maintenance program in place?

	N=448	
Yes	247	55.1%
No	201	44.9%

	CWS N=119		TNCWS N=60		NTNC N=51	
Yes	64	53.8%	33	55.0%	35	68.6%
No	55	46.2%	27	45.0%	16	31.4%

	ID N=230		NID N=218	
Yes	132	57.4%	115	52.8%
No	98	42.6%	103	47.2%

50. Are all water system valves exercised periodically?

	N=456	
Yes	264	57.9%
No	192	42.1%

	CWS N=122		TNCWS N=59		NTNC N=58	
Yes	69	56.6%	45	76.3%	37	63.8%
No	53	43.4%	14	23.7%	21	36.2%

	ID N=239		NID N=217	
Yes	151	63.2%	113	52.1%
No	88	36.8%	104	47.9%

51. Does the water system have a routine leak and repair program?

	N=453	
Yes	198	43.7%
No	255	56.3%

	CWS N=118		TNCWS N=59		NTNC N=57	
Yes	48	40.7%	23	39.0%	21	36.8%
No	70	59.3%	36	61.0%	36	63.2%

	ID N=234		NID N=219	
Yes	92	39.3%	106	48.4%
No	142	60.7%	113	51.6%

52. Are all meters routinely calibrated and tested?

	N=411	
Yes	95	23.1%
No	316	76.9%

	CWS N=113		TNCWS N=41		NTNC N=57	
Yes	21	18.6%	9	22.0%	15	26.3%
No	92	81.4%	32	78.0%	42	73.7%

	ID N=211		NID N=200	
Yes	45	21.3%	50	25.0%
No	166	78.7%	150	75.0%

53. Are parts readily available to repair the water system?

	N=462	
Yes	387	83.6%
No	47	10.2%
Don't know	28	6.0%

CWS N=113 TNCWS N=61 NTNC N=57

Yes	112	90.3%	43	70.5%	48	84.2%
No	10	8.1%	13	21.3%	7	12.3%
Don't know	2	1.6%	5	8.2%	2	3.5%

	ID N=242		NID N=220	
Yes	203	83.9%	184	83.6%
No	30	12.4%	17	7.7%
Don't know	9	3.7%	19	8.6%

54. Does a qualified pump or well contractor annually inspect pumps and pump motors?

N=461

Yes	138	29.9%
No	323	70.1%

	CWS N=123		TNCWS N=59		NTNC N=58	
Yes	37	30.1%	16	27.1%	19	32.8%
No	86	69.9%	43	72.9%	39	67.2%

	ID N=240		NID N=221	
Yes	72	30.0%	66	29.9%
No	168	70.0%	155	70.1%

55. Do you have a regular system for inspecting pumps and pump motors in between annual inspections?

N=457

Yes	144	31.5%
No	313	68.5%

	CWS N=122		TNCWS N=58		NTNC N=58	
Yes	40	32.8%	17	29.3%	17	29.3%
No	82	67.2%	41	70.7%	41	70.7%

	ID N=238		NID N=219	
Yes	74	31.1%	70	32.0%
No	164	68.9%	149	68.0%

56. Do all employees have a written job description for their position?

N=427

Yes	186	43.6%
No	241	56.4%

CWS N=118 TNCWS N=54 NTNC N=57

Yes	59	50.0%	22	40.7%	28	49.1%
No	59	50.0%	32	59.3%	29	50.9%

	ID N=229		NID N=198	
Yes	109	47.6%	77	38.9%
No	120	52.4%	121	61.1%

57. Does the water system have a workplace safety procedure in place?

N=433

Yes	189	43.6%
No	244	56.4%

	CWS N=120		TNCWS N=56		NTNC N=57	
Yes	63	52.5%	20	35.7%	23	40.4%
No	57	47.5%	36	64.3%	34	59.6%

	ID N=233		NID N=200	
Yes	106	48.5%	83	41.5%
No	127	54.5%	117	58.5%

58. Does the water system have an annual budget?

N=441

Yes	180	40.8%
No	261	59.2%

	CWS N= 124		TNCWS N=56		NTNC N=57	
Yes	87	70.2%	7	12.5%	21	36.8%
No	37	29.8%	49	87.5%	36	63.2%

	ID N=237		NID N=204	
Yes	115	48.5%	65	31.9%
No	122	51.5%	139	68.1%

58a. If the answer to Question 58 is “Yes”, is budget performance tracked monthly? (Answered “Yes” to #58)

N=169

Yes	120	71.0%
No	49	29.0%

	CWS N=84		TNCWS N=6		NTNC N=21	
Yes	58	69.0%	5	83.3%	11	52.4%
No	26	31.0%	1	16.7%	10	47.6%

	ID N=111		NID N=58	
Yes	74	66.7%	46	79.3%
No	37	33.3%	12	20.7%

(All respondents)
N=236

Yes	122	51.7%
No	114	48.3%

CWS N=94 TNCWS N=21 NTNC N=36

Yes	59	62.8%	6	28.6%	11	30.6%
No	35	37.2%	15	71.4%	25	69.4%

	ID N=151		NID N=85	
Yes	76	50.3%	46	54.1%
No	75	49.7%	39	45.9%

59. Does the budget include depreciation of existing facilities?

N=346

Yes	98	28.3%
No	248	71.7%

	CWS N=106		TNCWS N=41		NTNC N=45	
Yes	49	46.2%	3	7.3%	11	24.4%
No	57	53.8%	38	92.7%	34	75.6%

	ID N=192		NID N=154	
Yes	63	32.8%	35	22.7%
No	129	67.2%	119	77.3%

60. Are water rates regularly reviewed?

	N=354	
Yes	163	46.0%
No	191	54.0%

	CWS N=112		TNCWS N=37		NTNC N=43	
Yes	89	79.5%	6	16.2%	23	53.5%
No	23	20.5%	31	83.8%	20	46.5%

	ID N=192		NID N=162	
Yes	118	61.5%	45	27.8%
No	74	38.5%	117	72.2%

61. Is a schedule in place for budget or capital improvements?

	N=410	
Yes	196	47.8%
No	214	52.2%

	CWS N=120		TNCWS N=50		NTNC N=54	
Yes	79	65.8%	17	34.0%	32	59.3%
No	41	34.2%	33	66.0%	22	40.7%

	ID N=224		NID N=186	
Yes	128	57.1%	68	36.6%
No	96	42.9%	118	63.4%

62. Does the water system have an operating cash or emergency reserve fund?

	N=399	
Yes	204	51.1 %
No	195	48.9%

	CWS N=117		TNCWS N=49		NTNC N=52	
Yes	92	78.6%	15	30.6%	23	44.2%
No	25	21.4%	34	69.4%	29	55.8%

	ID N=218		NID N=181	
Yes	130	59.6%	74	40.9%
No	88	40.4%	107	59.1%

63. What is the average monthly residential water bill?

	N=268	
Mean $ Per month	$71.73	
Median $ per month	$20.00	
Don't know	96	35.8%

	CWS N=99		TNCWS N=21		NTNC N=33	
Mean $ Per month	$39.47		$7.33		$13.00	

Median $ per month	$19.35		0		$20.00	
Don't know	7	7.1%	12	57.1%	24	72.7%

	ID N=153		NID N=115	
Mean $ Per month	$34.68		$99.31	
Median $ per month	$19.35		$15.97	
Don't know	43	28.1%	53	46.1%

*Not all systems appear to charge by the month.

64. What is the average monthly residential water usage?

N=339

Gallons per month mean	749792	
Gallons per month median	5500	
Don't know	152	44.8%

	CWS N=114		TNCWS N=21		NTNC N=37	
Gallons per month mean	56694		20638		14788	
Gallons per month median	5250		8000		5500	
Don't know	21	18.4%	12	57.1%	16	43.2%

	ID N=186		NID N=153	
Gallons per month mean	46901		22932	
Gallons per month median	5500		4700	
Don't know	63	33.9%	89	58.2%

65. Has the water system considered reducing costs by consolidating facilities/management with another water system?

N=409

Yes	68	16.6%
No	302	73.8%
Don't know	39	12.9%

	CWS N=118		TNCWS N=53		NTNC N=50	
Yes	25	21.2%	5	9.4%	12	24.0%
No	88	74.6%	38	71.7%	34	68.0%
Don't know	5	4.2%	10	18.9%	4	8.0%

	ID N=221		NID N=188	
Yes	42	19.0%	26	13.8%
No	160	72.4%	142	75.5%
Don't know	19	8.6%	20	10.6%

66. If the water system had the option to consolidate physical facilities with another system would it be interested?

N=433

Yes	120	27.7%
No	211	48.7%
Don't know	102	23.6%

	CWS N=123		TNCWS N=56		NTNC N=55	
Yes	34	27.6%	12	21.4%	28	50.9%
No	55	44.7%	34	60.7%	19	34.5%

Don't know	34	27.6%	10	17.9%	8	14.5%

	ID N=234		NID N=199	
Yes	74	31.6%	46	23.1%
No	108	46.2%	103	51.8%
Don't know	52	22.2%	50	25.1%

67. If it had the option to consolidate administration/management with other systems would it be interested?

N=419

Yes	92	22.0%
No	211	50.4%
Don't know	116	27.7%

	CWS N=116		TNCWS N=54		NTNC N=55	
Yes	21	18.1%	9	16.7%	24	43.6%
No	58	50.0%	32	59.3%	16	29.1%
Don't know	37	6.8%	13	24.1%	15	27.3%

	ID N=225		NID N=194	
Yes	54	24.0%	38	19.6%
No	106	47.1%	105	54.1%
Don't know	65	28.9%	51	26.3%

68. At what financial level does the water system operate?
N=287

Surplus	63	22.0%
Loss	55	19.2%
Break-even	169	58.9%

	CWS N=111		TNCWS N=26		NTNC N=37	
Surplus	37	33.3%	3	11.5%	6	16.2%
Loss	15	13.5%	7	26.9%	10	27.0%
Break-even	59	53.2%	16	61.5%	21	56.8%

	ID N=174		NID N=113	
Surplus	46	26.4%	17	15.0%
Loss	32	18.4%	23	20.4%
Break-even	96	55.2%	73	64.6%

69. Does the water system use a standardized accounting system?

N=354

Yes	150	42.4%
No	151	42.9%
Don't know	52	14.7%

	CWS N=115		TNCWS N=41		NTNC N= 47	
Yes	88	76.5%	3	7.3%	12	25.5%
No	16	13.9%	31	75.6%	29	61.7%
Don't know	11	9.6%	7	17.1%	6	12.8%

	ID N=203		NID N=151	
Yes	103	50.7%	47	31.1%
No	76	37.4%	76	50.3%
Don't know	24	11.8%	28	18.5%

70. Does the water system have a policy in place for handling customer complaints?
N=364

Yes	237	65.1%
No	127	34.9%

CWS N=384 TNCWS N=42 NTNC N=48

Yes	94	81.7%	19	45.2%	30	62.5%
No	21	18.3%	23	54.8%	18	37.5%

	ID N=205		NID N=159	
Yes	143	69.8%	94	59.1%
No	62	30.2%	65	40.9%

71. Does the water system have access to other revenue sources besides customers?
N=373

Yes	152	40.8%
No	196	52.5%
Don't know	25	6.7%

	CWS N=115		TNCWS N=40		NTNC N=47	
Yes	49	42.6%	10	25.0%	17	36.2%
No	64	55.7%	26	65.0%	23	48.9%
Don't know	2	1.7%	4	10.0%	6	12.8%

	ID N=201		NID N=172	
Yes	76	37.8%	76	44.2%
No	113	56.2%	83	48.3%
Don't know	12	6.0%	13	7.6%

72. Is system designed to be easily upgraded in the event of new requirements or technologies?
N=403

Yes	254	63.0%
No	149	37.0%

	CWS N=117		TNCWS N=51		NTNC N=53	
Yes	87	74.4%	10	60.8%	25	47.2%
No	30	25.6%	26	39.2%	28	52.8%

	ID N=221		NID N=182	
Yes	143	64.7%	111	61.0%
No	78	35.3%	71	39.0%

Section D.Emergency Preparedness

73. Does the water system have an Emergency Response Plan in place?

N=439

Yes	149	33.9%
No	290	66.1%

	CWS N=120		TNCWS N=57		NTNC N=55	
Yes	47	39.2%	15	26.3%	13	23.6%
No	73	60.8%	42	73.7%	42	76.4%

	ID N=232		NID N=207	
Yes	75	32.3%	74	35.7%
No	157	67.7%	133	64.3%

74. Are all employees trained for emergency response?

N=414

Yes	176	42.5%
No	238	67.5%

	CWS N=116		TNCWS N=52		NTNC N=54	
Yes	68	58.6%	16	30.8%	21	38.9%
No	48	41.4%	36	69.2%	33	60.1%

	ID N=222		NID N=192	
Yes	105	47.3%	71	37.0%
No	117	52.7%	121	63.0%

75. Is there an emergency call-up list available for emergency situations?

N=418

Yes	278	66.5%
No	140	33.5%

	CWS N=119		TNCWS N=52		NTNC N=55	
Yes	100	84.0%	23	44.2%	45	81.8%
No	19	16.0%	29	55.8%	10	18.2%

	ID N=226		NID N=192	
Yes	168	18.4%	110	37.0%
No	58	81.1%	82	63.0%

76. Have neighboring utilities been contacted to pursue emergency interties?

N=395

Yes	63	15.9%
No	332	83.8%

CWS N=113 TNCWS N=50 NTNC N=48

Yes	32	28.3%	4	8.0%	3	6.3%
No	81	70.7%	46	92.0%	45	93.8%

	ID N=211		NID N=184	
Yes	39	18.5%	24	13.0%
No	172	81.5%	160	87.0%

77. Has a vulnerability analysis been conducted to determine where the water system weaknesses exist?

N=412

Yes	65	15.8%
No	347	84.2%

	CWS N=117		TNCWS N=48		NTNC N= 54	
Yes	30	25.6%	4	8.3%	12	22.2%
No	87	74.4%	44	91.7%	42	77.8%

	ID N=219		NID N=193	
Yes	46	21.0%	19	9.8%
No	173	79.0%	174	90.2%

78. Have different operational responses been considered for different emergency scenarios?

N=411

Yes	109	26.5%
No	302	73.5%

	CWS N=118		TNCWS N=50		NTNC N=54	
Yes	43	36.4%	9	18.0%	10	18.5%
No	75	63.6%	41	82.0%	44	81.5%

	ID N=222		NID N=189	
Yes	62	27.9%	47	24.9%
No	160	72.1%	142	75.1%

79. Does the water system have an emergency power supply?

N=465

Yes	92	19.8%
No	373	80.2%

	CWS N=125		TNCWS N=62		NTNC N=56	
Yes	36	28.8%	7	11.3%	7	12.5%
No	89	71.2%	55	88.7%	49	87.5%

	ID N=243		NID N=222	
Yes	50	20.6%	42	18.9%
No	193	79.4%	180	81.1%

80. If the answer to Question 83 is “Yes”, are these systems tested regularly?
- Data useless because typing error confused respondents

Section E. Records

81. Which of the following records are kept (check all that are):

N=456

Water quality testing	447	98.0%
Water consumption rates	305	66.9%
Customer complaints	148	32.5%
History, size, location and type of service mains	228	50.0%
Location of valves and hydrants	261	57.2%
Existing equipment and supplies	195	42.8%
List of chemicals used by system	169	37.1%

	CWS N=126		TNCWS N=73		NTNC N=58	
Water quality testing	121	96.0%	60	82.2%	57	98.3%
Water consumption rates	118	93.7%	21	28.8%	38	65.5%
Customer complaints	77	61.1%	9	12.3%	11	19.0%
History, size, location and type of service mains	105	83.3%	11	15.1%	23	39.7%
Location of valves and hydrants	104	82.5%	23	31.5%	33	56.9%
Existing equipment and supplies	76	60.3%	14	19.2%	16	27.6%
List of chemicals used by system	52	41.3%	18	24.7%	19	32.8%

	ID N=257		NID N=242	
Water quality testing	238	92.6%	209	86.4%
Water consumption rates	177	68.9%	128	52.9%
Customer complaints	97	37.7%	51	21.1%
History, size, location and type of service mains	139	54.1%	89	36.8%
Location of valves and hydrants	160	62.3%	101	41.7%
Existing equipment and supplies	106	41.2%	89	36.8%
List of chemicals used by system	89	34.6%	80	33.1%

82. Are records stored in a safe accessible place in the event of emergency?

N=436

Yes	403	92.4%
No	33	7.6%

	CWS N=122		TNCWS N=55		NTNC N=56	
Yes	118	96.7%	46	83.6%	56	100%
No	4	3.3%	9	16.4%	0	0

	ID N=233		NID N=203	
Yes	220	94.4%	183	90.1%
No	13	5.6%	20	9.9%

Section F.Computer and Internet Access

83. Does the water system have a computer?

N=459

Yes	131	28.5%
No	328	71.5%

	CWS N=125		TNCWS N=62		NTNC N=58	
Yes	73	58.4%	5	8.1%	15	25.9%
No	52	41.6%	57	91.9%	43	74.1%

	ID N=245		NID N=214	
Yes	93	38.0%	38	17.8%
No	152	62.0%	176	82.2%

83a. If the answer to Question 83 is “Yes”, which of the following is the computer used for (check all that apply):

	N=131	
Record-keeping	116	87.0%
Word-processing	92	70.2%
E-mail	53	39.7%
Internet access	52	39.7%
Other	17	11.5%

	CWS N=73		TNCWS N=59		NTNC N=15	
Record-keeping	64	87.7%	5	6.8%	11	73.3%
Word-processing	48	65.8%	5	6.8%	9	60.0%
E-mail	27	35.6%	4	8.5%	5	33.3%
Internet access	26	35.6%	4	8.5%	4	26.7%
Other	11	15.1%	1	1.7%	2	6.7%

	ID N=85		NID N=38	
Record-keeping	80	94.1%	36	94.7%
Word-processing	62	72.9%	30	78.9%
E-mail	36	42.4%	17	44.7%
Internet access	34	40.0%	18	47.4%
Other	14	16.5%	3	7.9%

83. What is the water systems, or contact persons, E-mail address:

84. Does the water system have a homepage address.

Appendix B. Technical Addendum

1.1.2. **System knowledge**

The following method was used to calculate the system knowledge variable:

Survey Question #	Question	Score
1	Treatment process used by the system known:	Plus 3
7	Depth of wells known:	Plus 1
20	Age of the water system known:	Plus 3
25	Average gallons per day pumped known:	Plus 1.5
26	Gallons per day on a peak day known:	Plus 1.5
32	List of all federal, state, and other standards:	Plus 3
37	High and low pressure in the system known:	Plus 1
38	Use of backflow protection devices known:	Plus 1
39	Existence of dead-ends in the system	Plus 1
40	Suitability of right-of-ways	Plus 1
41	Sufficiency of earth cover over lines	Plus 1
42	Materials used for line mains	Plus 1
	Total:	19

To achieve an overall score between 1 and 10, the total points were divided by 19 (the maximum possible) and multiplied by 10. In the event that a respondent did not respond to a question, the maximum score was reduced by the amount of the unanswered question so as not to inappropriately count a null response as a negative one.

1.1.3. **Source Knowledge**

The following method was used to calculate the system knowledge variable:

Survey Question #	Question	Score
5	Influence of surface water supply on the source known	Plus 1
9	Boundary of the well recharge area known	Plus 1
14	Awareness of other users of the source	Plus 1
14a	Aware of the level other use same source	Plus 1
15	Knowledge of pollution sources within the recharge area	Plus 1
16	If farms exist, the familiarity with farming practices	Plus 1
17	Planning efforts within the recharge area known	Plus 1
18	Existence of a source conservation plan	Plus 1
19	Availability of alternate sources known	Plus 1
19a	Details of using alternate sources known	Plus 1
	Total:	10

To achieve an overall score between 1 and 10, the total points were divided by 10 (the maximum possible) and multiplied by 10. In the event that a respondent did not respond

to a question, the maximum score was reduced by the amount of the unanswered question so as not to inappropriately count a null response as a negative one.

Appendix C. Chi Square Calculation

Using the column and row totals, a Chi-square test generates a set of 'expected counts' for each cell of the chart. If the results were purely chance, this is what outcome should be. If they differ from the expected values, a Chi-square is calculated and a significance level determined. If the significance level is < .05 the relationship is not by chance. To be accurate no more than 20% of the cells can have a count less than five. To ensure that each cell was greater than 5, two cells were combined to form one new one (i.e. 1&2 became 1).

ANYMCL * OPERATN Crosstabulation

			OPERATN					
			1	2	3	4	5	Total
ANYMCL	0	Count	8	26	61	94	26	215
		Expected Count	6.7	23.3	55.8	102.5	26.7	215.0
	1	Count	0	2	6	29	6	43
		Expected Count	1.3	4.7	11.2	20.5	5.3	43.0
Total		Count	8	28	67	123	32	258
		Expected Count	8.0	28.0	67.0	123.0	32.0	258.0

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	10.626[a]	4	.031
Likelihood Ratio	12.439	4	.014
Linear-by-Linear Association	7.119	1	.008
N of Valid Cases	258		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.33.

Appendix D. PHPA Review Checklist

Using the Water System Plan, records of Sanitary Surveys, records of regulation compliance, and operator certifications review the following items for the water system:

System Management:

Does the system have an adequate financial plan including an annual budget?	__ Pass __ Advise __ Fail
Does the system have an appropriate preventive maintenance program in place?	__ Pass __ Advise __ Fail
Does the system have an adequate number of certified operators?	__ Pass __ Advise __ Fail
Does the system have appropriate and sufficient operations procedures?	__ Pass __ Advise __ Fail
Do effective policies exist for such issues as new construction, cross-connections, dead-ends, materials used, record keeping, etc.?	__ Pass __ Advise __ Fail

System Characteristics

Does the system have an adequate inventory of its facilities?	__ Pass __ Advise __ Fail
Does a map exist of the entire system including interties and connections?	__ Pass __ Advise __ Fail

Source Knowledge, Protection, and Conservation

Does the system have a plan for source protection?	__ Pass __ Advise __ Fail
Does the system have a source conservation program?	__ Pass __ Advise __ Fail
Does the system have sufficient knowledge of other related plans?	__ Pass __ Advise __ Fail
Does the system know how much water is pumped daily?	__ Pass __ Advise __ Fail
Does the system know the capacity of its source?	__ Pass __ Advise __ Fail

Future Planning

Has the system projected demand for 6 and 20 years into the future?	__ Pass __ Advise __ Fail
Does a plan exist for expansion to meet these demands?	__ Pass __ Advise __ Fail

Is the system planning for replacement or renewal? __ Pass __ Advise __ Fail

Emergency Preparedness

Does the system have an Emergency Response Plan? __ Pass __ Advise __ Fail

Does the system have sufficient storage and/or alternative sources? __ Pass __ Advise __ Fail

Does the system have an emergency power supply? __ Pass __ Advise __ Fail

Are records kept in a safe location? __ Pass __ Advise __ Fail

Is there a plan to regularly test facilities to avoid system failure? __ Pass __ Advise __ Fail

Records

Does the system have a list of all applicable regulations? __ Pass __ Advise __ Fail

Does the system have an adequate record keeping system? __ Pass __ Advise __ Fail