Chapter 8
Drinking Water

NEW HAMPSHIRE
DEPARTMENT OF
Environmental
Services

Overview

New Hampshire has an abundant supply of clean drinking water. There are challenges, however, for the public water systems that serve 64 percent of New Hampshire's population and for the remaining 36 percent of residents that rely on private, household drilled or dug wells (NHDES, 2008a). Drinking water from public water supplies is highly regulated to protect public health, but aging infrastructure and the cost of treating drinking water and otherwise meeting ever increasing regulatory requirements are significant issues for public water suppliers. Few public water systems in New Hampshire charge the true cost of providing water or have adequately planned to maintain and replace infrastructure that is decades old. Also, as our ability to detect and evaluate contaminants in drinking water has increased, so has the need to address more contaminants to protect public health. A recent example of this phenomenon is the presence of trace amounts of personal care products and pharmaceuticals in some water supply sources. The wisdom of treating all water to drinking water standards, water which is then used for non-drinking water purposes, is being addressed elsewhere in the country and needs to be considered in New Hampshire as well. Because of New Hampshire's rural nature, there is a large proportion of very small community public water systems, many of which are hard-pressed to meet the same requirements as larger systems, but with far fewer resources.

For both private well owners and public water systems that use wells, naturally occurring contaminants such as radon and arsenic are significant health concerns. Unlike public water systems, there is no requirement for private well water to be tested or treated, and many people in New Hampshire are unknowingly drinking water that exceeds health-based contaminant limits.

Finally, New Hampshire is a nationally recognized leader in protecting the groundwater and surface water that are the sources of drinking water. Still, landscape change has the potential to degrade our sources of drinking water by contributing contaminants and changing hydrology as described in Chapter 1 – Introduction and Overview.

8.1 Description and Significance

8.1.1 Drinking Water Is Critical to Health and Quality of Life

Human life depends on water. The average human can live 40 days or more without food, but only three to five days without water (Kendall, 1991). Drinking water is also used for food production and preparation, sanitation, outdoor irrigation, industrial processes and for many other activities.

The importance of drinking water and its protection was recognized 400 years ago at colonial Jamestown, Va., (see sidebar) and has been an acknowledged public health priority for centuries in the U.S. Unlike in developing countries, fewer than 1 percent of U.S. residents lived without complete indoor plumbing by the year 2000 (Rural Community Assistance Partnership, n.d.). As a result, diseases caused by unclean water supplies are much rarer in the U.S. Waterborne disease outbreaks, however, continue to occur in the U.S. and the endemic waterborne disease burden is significant. Recently, an expert panel of scientists from the Centers for Disease Control and Prevention and the U.S. Environmental Protection Agency estimated that 5.5 million to 32.8 million cases of acute gastrointestinal illness per year are attributable to community drinking water systems in the U.S. (Messner et al., 2006).

> **"There shall be no man or woman dare to wash any unclean linen, wash clothes, ...nor rinse or make clean any kettle, pot or pan, or any suchlike vessel within twenty feet of the old well or new pump. Nor shall anyone aforesaid within less than a quarter mile of the fort, dare to do the necessities of nature, since by these unmanly, slothful, and loathsome immodesties, the whole fort may be choked and poisoned."**
>
> *- Governor Gage of Virginia, 1610*
>
> (Source: Virginia Dept. of Health, 2007)

8.1.2 New Hampshire Water Supply: Where Do We Get Our Drinking Water and How Is It Tested?

Private Wells

An estimated 36 percent of New Hampshire residents obtain their drinking water from private wells with roughly 4,700 new wells constructed each year. There are two main types of private wells in New Hampshire: bedrock wells and shallow dug wells. The type of well used is largely dependent on local soil types and water availability on the property. An estimated 90 percent of all new wells are bedrock wells, which can be from 100 to 700 feet deep, depending on where an adequate supply or yield is reached (NHDES, 2008c).

Since 2000, private wells have had to meet statewide design criteria for construction and placement (We 100-1000), but there are no clear state requirements for minimum well water quality or quantity. The State Plumbing Code requires that only potable water sources be connected to domestic plumbing systems, but this requirement is not uniformly applied, in part due to confusion about the meaning of "potable" and the absence of specific water quality standards. When homes are sold, the owner must disclose information about both the water supply system and the wastewater disposal system, including the date of the most recent water test and whether the seller has experienced a problem such as an unsatisfactory water test (RSA 477:4-c), but there is no requirement to do a test. As a result, private wells are usually only tested when the buyer chooses to do so, when a lender requires it at the time of sale, when a homeowner has a new well drilled by a contractor who recommends a test, when problems with water quality are noticeable, or in those few towns where a private well water test is required for a certificate of occupancy or for property transfer. There are also no state standards in regards to treatment of water from private wells.

Public Water Systems

A public water system is defined as "a piped water system having its own source of supply, serving 15 or more services or 25 or more people, for 60 or more days per year" (RSA 485:1-a). Public water systems must meet all the requirements of the federal and state Safe Drinking Water Acts. These requirements have increased over time.

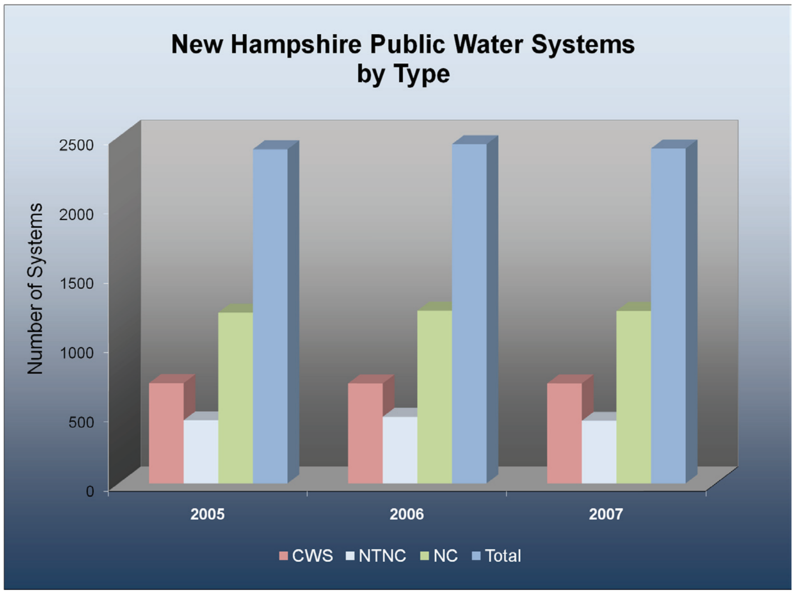

Figure 8-1. New Hampshire public water system profile: Community water system (CWS); non-transient/non-community (NTNC); transient/non-community (NC). ***Source: NHDES, 2008a.***

There are three types of public water systems: community water systems; non-transient/non-community systems; and transient systems. Depending on the type of system, the requirements vary, with more stringent requirements for larger systems and for those serving residential populations. Figure 8-1 shows the number of New Hampshire's public water systems among these categories. Each is described briefly below.

In 2007 there were 721 community water systems (CWSs) serving a combined resident population of approximately 849,905 (average size: 1,179) (NHDES, 2008a). These include municipalities, apartments and condominiums, mobile home parks, and single family home developments. Ninety-five percent of the CWSs in New Hampshire are small systems serving fewer than 3,300 residents. There are also 36 medium CWSs that each serve between 3,300 and 50,000 people, and two that are classified as large systems serving more than 50,000 each – Manchester Water Works and Pennichuck Water Works in the Nashua area (Figure 8-2) (NHDES, 2008a). The largest systems primarily use surface water for their source of supply, while the majority of small systems use groundwater.

The largest community systems are required to do the most comprehensive monitoring and treatment. Currently community systems must monitor for over 100 contaminants on a relatively frequent basis.

In 2007 there were 451 non-transient/non-community water systems (NTNCs) in New Hampshire (NHDES, 2008a). Typical NTNCs include non-residential schools, day cares, office buildings, commercial and industrial buildings, and

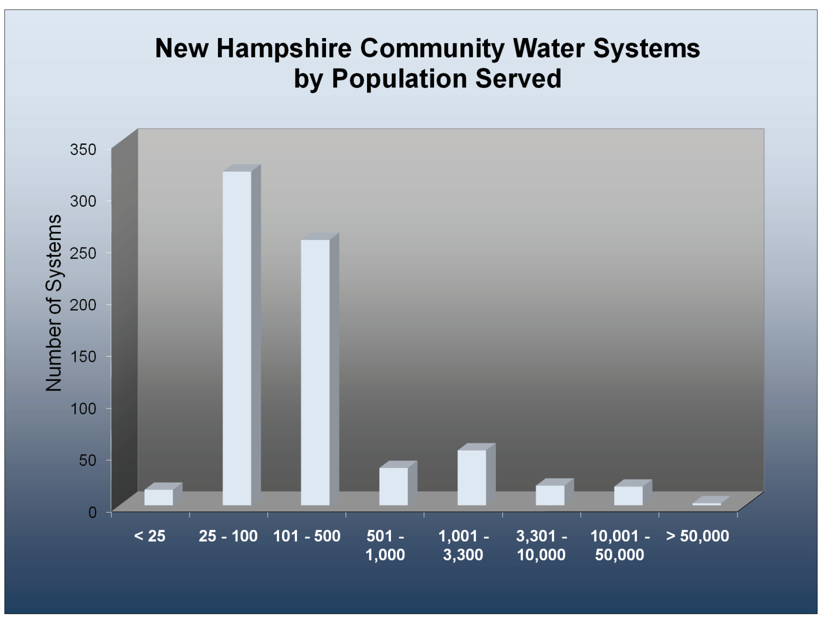

Figure 8-2. Of community water systems, the majority (82%) serve relatively small populations that have fewer than 500 customers. ***Source: NHDES, 2008a.***

businesses with permanent employees. Nineteen percent of New Hampshire's public water systems are NTNCs. This is larger than any of the other New England states and is a reflection of New Hampshire's rural nature. On average, these systems only serve about 200 people each, so there is often little economy of scale compared to community water systems.

All of New Hampshire's NTNC systems use groundwater for their source of water. The system operator is required to monitor for bacteria, lead and copper, nitrate, nitrite, inorganic contaminants (metals), volatile organic compounds or VOCs (solvents and hydrocarbons), and synthetic organic compounds or SOCs (pesticides). However, the sampling frequencies are less than for community systems and the compliance schedules for various treatment needs and monitoring are usually delayed until after community systems have complied.

In 2007 New Hampshire reported that there were 1,244 Transient/Non-Community Water Systems. Typical transient systems include restaurants, motels, hotels, ski areas, beaches and camp-grounds (NHDES, 2008a). All but one of these transient systems rely on groundwater for their source of water. Transient systems are only required to monitor for bacteria, nitrate and nitrite.

As indicated in Figure 8-3, 38 percent of the population served by CWSs is served by systems using only groundwater, 39 percent by systems using only surface water, and 23 percent by systems using both groundwater and surface water sources.

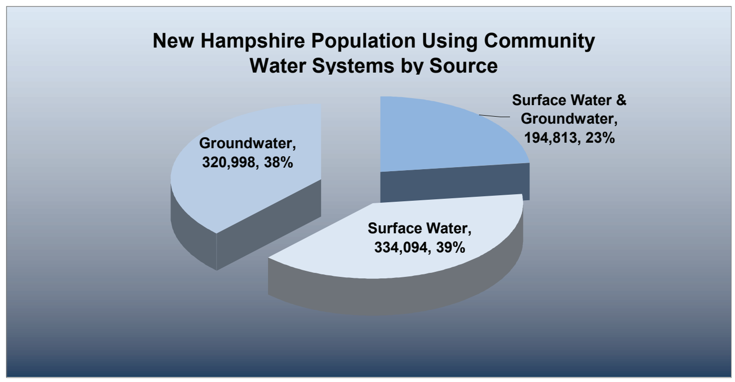

Figure 8-3. Population served by New Hampshire's community water systems. ***Source: NHDES Drinking Water and Groundwater Bureau.***

8.1.3 Drinking Water Uses and Statistics

Between 1950 and 2000 the U.S. population nearly doubled, but during the same period public demand for water more than tripled. Americans now use an average of 100 gallons of water each day, even though only two or three gallons might actually be consumed or used in cooking (U.S. Environmental Protection Agency [USEPA], 2008b). Indoor use varies but is typically around 70 gallons, nearly half of this for toilet flushing and clothes washers. That leaves nearly 30 gallons as outside water use for lawns, gardens and car washing (American Water Works Association, 2008). A recent study of the New Hampshire Seacoast estimated that each person uses an average of 75 gallons per day, although usage varied greatly among communities (Horn et al., 2008). A number of public water systems in New Hampshire report a doubling of customers' water use in the summer months due to irrigation. (See also Chapter 7 – Water Use and Conservation.)

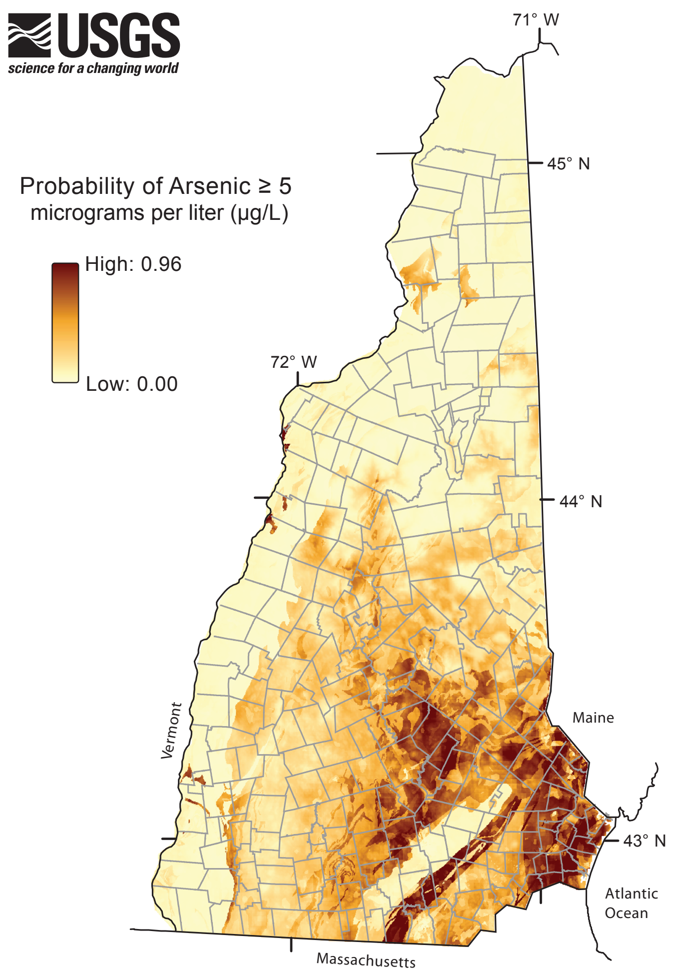

Figure 8-4. Probability that wells in each area of New Hampshire are likely to have water with arsenic concentrations exceeding 5 micrograms per liter (µg/L). ***Source: Ayotte et al., 2006b.***

8.1.4 Estimates of Naturally Occurring Contaminants in New Hampshire Well Water

New Hampshire's geology lends itself to certain common, naturally occurring contaminants, the most predominant being arsenic and radon. There are also iron and manganese deposits that can create common aesthetic concerns such as unpleasant taste and odor and unwanted staining. Our understanding of naturally occurring contaminants in well water is largely derived from the testing required at public water systems, the voluntary testing of private wells, and a number of scientific studies by USGS and others. It should be noted that many private wells are never tested.

Arsenic in well water is fairly widespread in New Hampshire (Figure 8-4). It is estimated that 20 percent of the state's private wells exceed the recently revised standard of 10 parts per billion of arsenic, which public systems must not exceed (Moore, 2004; Ayotte et al., 2006a). Although most of the arsenic in groundwater is likely of geologic origin, some of it may also be from historic pesticide use on apple orchards and other crops or from ash disposal (Robinson & Ayotte, 2006). Arsenic is a known carcinogen.

Radon gas is a byproduct of the radioactive decay of radium in certain rocks such as granite, so it is naturally common in the Granite State (Figure 8-5). Radon is a carcinogen. The major pathways to people are via migration of the gas through the soil and into homes where it may be inhaled, through groundwater entering the home as drinking water and then released as a gas, such as when showering or running water, and through ingestion of drinking water. The greatest exposure is through the first pathway.

Drinking water standards for radon have been quite controversial, with an initial proposal from U.S. Environmental Protection Agency of 300 picocuries per liter (pci/L), a limit that would have been exceeded by an estimated 95 percent of all New Hampshire wells. That standard was never finalized and it is unclear when a federal standard will emerge. Some New England states have set standards ranging from 4,000 – 10,000 pci/L and DES recommends that treatment be considered if the levels in well water exceed 2,000 pci/L. Nearly 40 percent of New Hampshire's wells are estimated to exceed 4,000 pci/L (NHDES, 2005). Other, less predominant naturally occurring contaminants found in some areas of the state include other radionuclides, fluoride and beryllium. Manganese at very high levels has also emerged as a health concern.

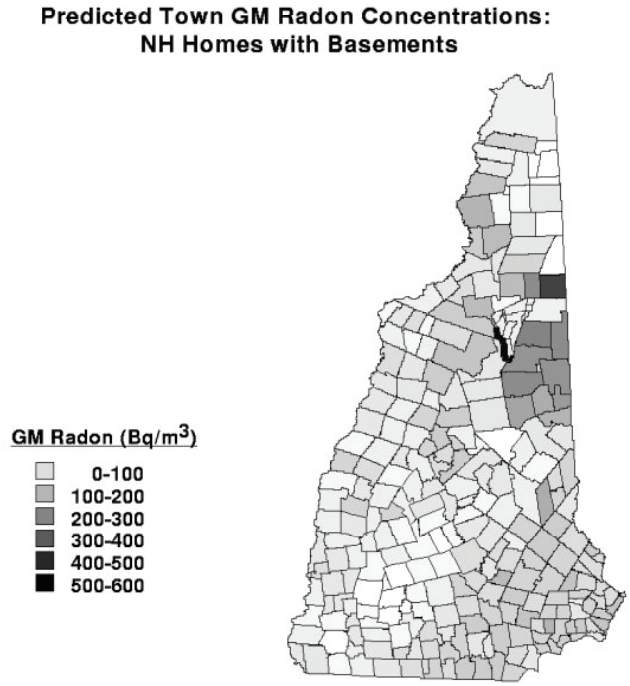

Figure 8-5. Predicted geometric mean (GM) concentrations of radon in homes with basements, by Town. ***Source: Apte et al., 1999.***

8.1.5 Water Supply System Components and Costs

Infrastructure in private water supply systems is minimal, consisting typically of a well, a pump, piping to the home, and a pressure tank. If there are water quality problems, the homeowner may have a point-of-entry device that treats all of the water entering the home, such as for radon. Alternatively, some homeowners are able to use point-of-use devices under the sink that treat only the drinking water coming from the tap, such as for arsenic. Older plumbing within the home may contain lead solder and fixtures that can leach lead and copper into the water. As previously noted, there is no uniform set of private well testing requirements or standards for treatment in New Hampshire, leaving it up to the homeowner to test their water and deal with the quality issues.

Almost all private and small community water sources are wells, either dug or bedrock as previously described. As the number of customers increases, it can become difficult to meet demands through wells. As a result, larger systems most often rely on surface water sources or a combination of surface and groundwater.

The infrastructure for public water systems includes additional components such as treatment, storage, pumping and distribution. Typically, the larger the system, the more complex the system components, with surface water systems generally requiring significantly more treatment than groundwater based systems. For many of New Hampshire's municipal systems, the infrastructure is decades if not centuries old. Therefore, routine and long-term maintenance of treatment and water distribution systems are important.

The sophistication of system monitoring and management also varies greatly. Generally, the larger systems can afford to have computerized monitoring and control systems and multi-level staffing, while smaller systems often struggle to cover the costs of basic treatment, monitoring and maintenance.

8.1.6 Multiple Barrier Approach to Safe Drinking Water

As regulations under the Safe Drinking Water Act have become more and more inclusive and stringent in response to new information about contaminants and their health impacts, water systems that once needed only basic treatment have had to implement more complex processes. Treatment,

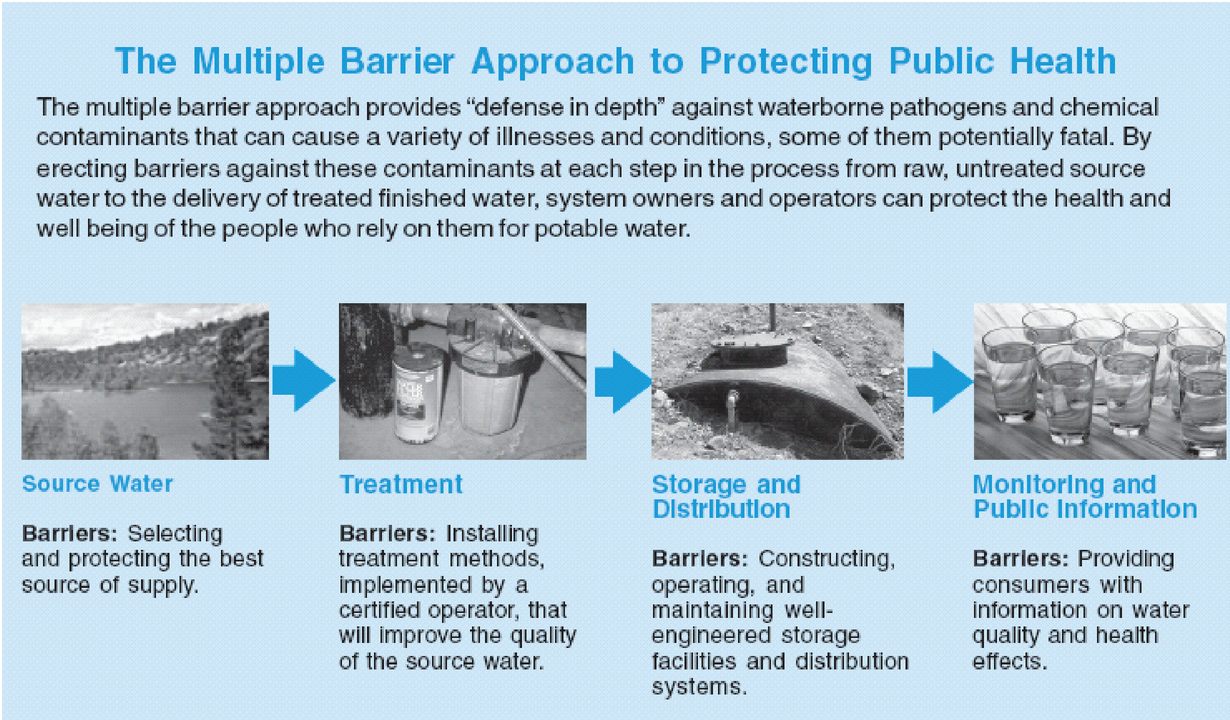

Figure 8-6. Multiple-barrier approach to safe drinking water. ***Source: USEPA, 2003.***

however, is only one element of an overall approach to ensuring safe drinking water that has been adopted over time by both the EPA and the water supply industry. The multiple barrier approach is now firmly established as the preferred way to ensure safe drinking water, although many water systems have employed the elements of this approach for many decades.

The multiple barrier approach may be slightly different for each type of system, but in general it includes steps that go all the way from the source of the drinking water to the tap. For example, a typical surface water multiple barrier approach includes watershed protection focusing on managing land uses and water-based activities, possibly optimization of the intake(s) to draw water from the location where water quality is optimal, a series of chemical and physical treatment steps including filtration and disinfection, protected storage of the treated water, monitoring steps, distribution system operations and maintenance, ongoing operator training, and additional tap water monitoring. Each of these provides a partial barrier to pathogens and chemical contamination, and together, public health is well-protected. Figure 8-6 shows the multiple-barrier approach graphically.

The multiple barrier approach can also be used for private wells. The steps are simpler but no less important, and may include using a reputable contractor to construct the well, locating it properly to avoid exposure to sanitary waste or other contaminants, keeping harmful materials away from the well, avoiding the use of nitrate fertilizers and pesticides nearby, disinfection of the piping to the house, testing of the well before use and every three years thereafter, installation and maintenance of appropriate treatment if indicated, and the use of backflow prevention devices wherever irrigation connections occur.

New Hampshire has embraced this approach and has promoted protection of the sources of our drinking water as an important tool in ensuring safe drinking water. The state supports local land use planning consistent with protecting both the quantity and quality of drinking water and many municipalities have adopted ordinances to protect their drinking water.

8.2 Issues

8.2.1 Private Well Users at Risk

Although about 36 percent of New Hampshire residents use private wells for their drinking water supply, the water quality of many of these wells is unknown. Currently there are no statewide monitoring or treatment requirements for private wells. Private wells are not covered by the Safe Drinking Water Act and are rarely regulated in towns or other states. New Hampshire has required a well construction report for private wells since the year 2000; however, there may be no records for wells constructed before then. Further, while New Hampshire encourages private well testing, it is unclear how effective the educational efforts have been.

As previously described, estimates suggest that a significant proportion of New Hampshire's private bedrock wells are contaminated with arsenic and/or radon, two naturally occurring contaminants. Recent studies have also increased concern about the health risks of elevated manganese and fluoride in some areas (Rocha-Amador et al., 2007). Dug wells are often at risk for pathogen entry if they are improperly maintained or constructed, or if wells are located where contaminants might enter due to flooding, nearby animal pens, manure piles, etc. In addition, there are other less common contaminants such as radionuclides other than radon, fluoride or beryllium, which can occur at unsafe levels in particular geographic areas. Salt from roads or salt piles is also a common problem in many areas of the state.

8.2.2 New Hampshire Has a High Proportion of Struggling Small Community Systems

Even large community water systems find the Safe Drinking Water Act regulations difficult and costly to meet, so it is no surprise that it is much more difficult for small water systems. Figure 8-7 depicts the many challenges that small water systems may encounter as they provide safe drinking water. New Hampshire has a large proportion of small systems which are widely distributed and often impossible to interconnect. Per customer costs may be dramatically different than those associated with large systems. These small stand-alone systems require fairly sophisticated operations, yet they cannot afford to hire full-time staff that specialize in drinking water. Some small municipal water systems may have to share one part-time staff member with the highway department, the fire department and others.

Conversely, larger systems benefit from economies of scale and can afford to hire highly educated, specialized staff teams with in-depth knowledge of treatment, distribution, and other aspects of drinking water provisions. As a result, customers of the smallest systems often pay the most for

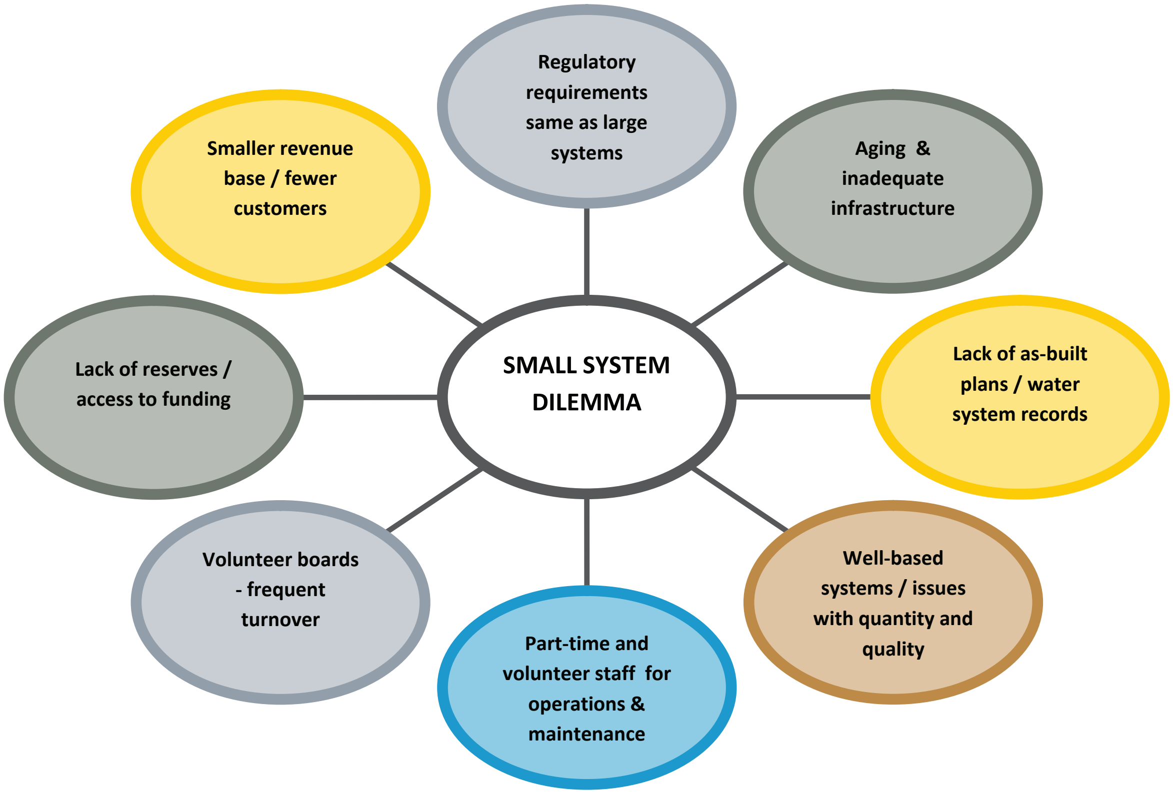

Figure 8-7. Challenges for small community water systems in New Hampshire.

the least in services. It is also important to note that providing water supply is a highly capital intensive mission where even the largest systems struggle to maintain and replace their aging infrastructure.

8.2.3 Aging Water Supply Infrastructure Is Widespread: Funding Insufficient

Much of the drinking water infrastructure in New Hampshire's cities and towns is 50 to100 years old. The infrastructure can include some or all of the following: dams for reservoirs, intakes, wells, pumps, transmission lines that take the water supply to treatment facilities, treatment facilities, water storage tanks, distribution networks, pump stations, meters, and electronic monitoring systems. Nearly all of these are costly to maintain or replace. Without regular capital improvements, more water leakage can occur and drinking water can become more difficult and costly to meet community needs.

A few of the largest systems are able to develop and implement long-term capital improvement plans, making infrastructure improvements over time. But for the most part, typical municipal systems are unable to keep up with the capital improvements that are needed to keep their systems up to date and operating efficiently, since they lack larger systems' economies of scale. Most water systems do not charge enough to cover all of the costs associated with providing water.

In 1996 a Drinking Water State Revolving Fund was established by Congress to, in part, help public water systems address aging infrastructure. New Hampshire receives approximately $8 million each year to loan out at reduced interest rates to our public water systems. In 2005 the 20-year projected demand for this funding in New Hampshire was $595.6 million (USEPA, 2005). Each year projects are prioritized based on severity of public health threat but demand consistently far exceeds supply. Because of the extensive process involved in receiving these loans, needy small public water systems rarely apply.

8.2.4 Population Pressures and the Purity Paradox

Treatment standards under the Safe Drinking Water Act are geared solely for the cost-effective protection of public health. Yet these stringent and costly standards are used to treat the entire water supply even though only a very small proportion of that water supply is actually used for drinking water. A considerable amount of water supply treated to drinking water standards is used to do laundry, flush toilets, irrigate lawns, put out fires, and clean streets.

Water systems expand to meet the peak demand of all uses, whether for drinking, lawn watering, or sanitary uses. Wells are drilled and re-drilled, surface water sources are expanded, and treatment capacity is increased to accommodate demand. Yet only a small portion of the total water used really needs to be of such high quality. There is a potential for both water and energy savings if non-drinking water uses could be satisfied by sources that are not treated to drinking water standards. Water from sinks and clothes washing (grey water) could be used for toilet flushing. Stormwater could be used to irrigate lawns with only minimal treatment in most cases. Until water costs much more, however, the savings associated with recycling grey water and stormwater will not outweigh the cost of separate conveyance systems.

This issue is likely to become more important in the future as population growth strains available supply and the cost of treatment continues to climb. As noted in Chapter 4 – Groundwater, continued growth and development also severely limits the ability to develop new municipal wells in many areas. Emerging contaminants that could drive the increase in treatment costs include pathogenic viruses, toxic algae, and pharmaceuticals and personal care products, e.g., prescription and over the counter therapeutic drugs, veterinary drugs, fragrances, cosmetics, sunscreen products, diagnostic agents and vitamins.

8.2.5 Climate Change May Have Implications for Public Health and Infrastructure

Some researchers are concerned that the rise of extreme precipitation events linked to climate change (see Chapter 1 – Introduction and Overview) will worsen U.S. waterborne disease outbreaks in the future. A 2001 article in the Journal of Public Health reported evidence that 68 percent of the waterborne disease outbreaks in the U.S. from 1948-1994 were preceded by the largest precipitation events (Curriero et al., 2001). It has not been determined whether this association holds true in New Hampshire. However, the predicted increase in frequency and intensity of storm events is a concern in terms of flooding at public water systems.

8.2.6 Water Supply Policies May Help or Hinder Smart Growth

Generally, land use patterns that concentrate growth in or near existing population centers and that involve compact development in newly developed areas are more protective of water resources and other aspects of environmental quality (air quality, energy use, consumption of other resources). There are several ways in which water supply policies on both the local and state levels may promote or hinder such "smart growth" land use patterns. First, as noted in section 8.2.4 and in Chapter 4 – Groundwater, attention should be given to the protection of future community well sites to enable growth of municipal systems in or near their existing service areas. Without this attention, these well sites will continue to be choked out by nearby development. Second, policies that address the expansion of service areas can either promote or hinder smart growth objectives, depending on the extent to which they encourage infill or compact development. Finally, the regulatory and financial demands on small community water systems may present an obstacle to compact development (as an alternative to large-lot development) outside existing service areas.

8.3 Current Management and Protection

8.3.1 Public Drinking Water Program

The New Hampshire Public Drinking Water Program implements the New Hampshire Safe Drinking Water Act (SDWA), which includes the requirements of the federal SDWA, which have expanded over the years (Figure 8-8). The federal SDWA was reauthorized in August 1996. New Hampshire has received "Primacy," the official designation by EPA for a state to implement the provisions of the federal SDWA. Approximately 90 percent of the funding for New Hampshire's Public Drinking Water Program comes from EPA, the remaining 10 percent comes from fees paid by water systems. Consequently, much of the work of DES's Drinking Water and Groundwater Bureau is dictated by the federal SDWA, including maximum contaminant levels (MCLs), monitoring schedules, and water system inspections. These requirements are designed to protect public health and were created at the national level in response to concerns expressed to the U.S. Congress regarding the need for

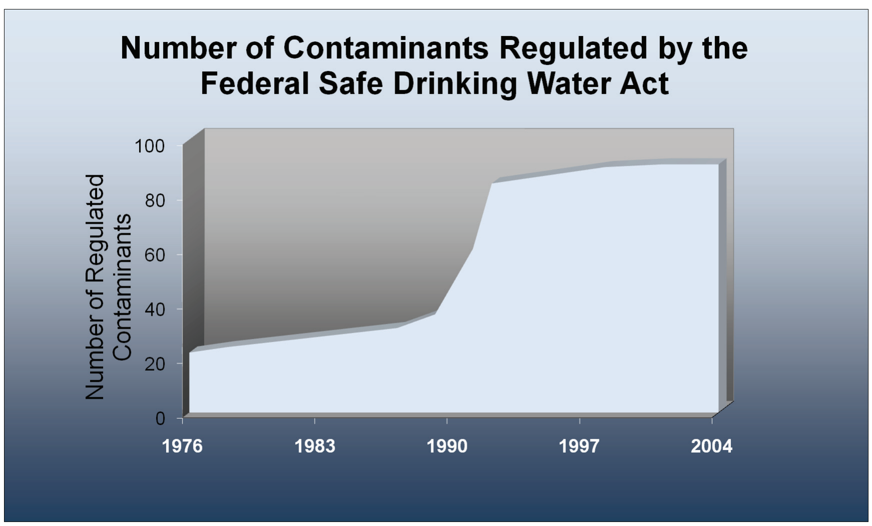

Figure 8-8. The number of contaminants regulated by the federal Safe Drinking Water Act has increased substantially over the past three decades. While compliance with the drinking water standards for so many contaminants proves to be difficult, this Figure does not account for regulatory standards that have changed to further limit a specific contaminant. *Source: USEPA, 2008a.*

strict standards in the drinking water industry. Overall, New Hampshire's drinking water program includes design, operation, and monitoring requirements for public water systems as well as protection of the sources of drinking water. In addition to DES, two public water system member groups have active roles in safe drinking water issues and provide significant training for public water system operators: New Hampshire Water Works Association and Granite State Rural Water Association. Finally, the Rural Community Assistance Program also provides assistance to public water systems in rural areas of the state.

8.3.2 Private Well Initiative

In 2000 DES and EPA launched a private well testing initiative, encouraging users of private wells to test their water more often and for a broader range of contaminants than before. DES enlisted the help of local health officers to blanket the state with posters and flyers urging homeowners to "Protect Your Family – Test Your Well's Water Quality Today." Health officers were asked to display the flyers in high-traffic locations in their municipalities. Public service announcements were produced and distributed to radio stations. A web site was developed containing pertinent fact sheets about contaminants of concern, lists of licensed well drillers and accredited laboratories, wellhead protection information, checklists, and other information for private well owners (NHDES, 2008e). Outreach to realtors and homeowners continue on a limited basis due to funding constraints.

8.3.3 Water Well Construction and Driller Licensing

Water well contractors and pump installers are licensed under RSA 482-B, which also establishes a Water Well Board to oversee licensing and the filing of well completion reports. The Water Well Board also adopts and enforces standards for the construction of wells and the installation of pumps. The board maintains records of over 112,000 wells constructed throughout the state since 1984 (NHDES, 2008d). The information is available for easy access through the internet, and is used frequently by homeowners, professionals such as hydrogeologists, and other interested parties.

8.3.4 Local Source Water Protection and Private Well Testing Ordinances

While a significant number of New Hampshire municipalities have taken steps to protect their important groundwater resources from contamination by human activities, very few have adopted regulations to protect private well users through mandatory testing. Seventy-five municipalities have adopted ordinances to protect aquifers, public wells, or other groundwater resources. Seventy of those ordinances rely on land use restrictions, while 27 incorporate a requirement for potential contamination sources to use best management practices. Twenty-one municipalities have adopted ordinances similar to the model groundwater protection ordinance developed by DES and the New Hampshire Office of Energy and Planning (NHDES, 2006), incorporating both land use restrictions and BMP requirements.

In contrast, only five municipalities have adopted ordinances that require testing of private wells for a prescribed list of contaminants, either in connection with real estate transfers or certificates of occupancy. An additional 44 municipalities report that they have a private well testing requirement, apparently in reference to the state plumbing code, which requires that water supplies connected to domestic plumbing systems supply potable water. However, the code does not define "potable" in terms of specific contaminants, so there is no assurance that the water is tested for common contaminants such as arsenic and radon.

8.4 Stakeholder Recommendations

8.4.1 Increase Private Well Protection

In spite of the major efforts towards protecting private wells by licensing contractors and drillers and requiring standards for well construction, there are no clear water quality or testing standards for private wells. There are also no mandatory state standards for vendors installing treatment for private wells. Since a large percentage of private wells produce water that exceeds health-based contaminant limits, additional steps are needed to improve the effectiveness of programs to inform and protect private well users.

8.4.2 Improve Capacity of Small Systems

New Hampshire has many small drinking water systems that are often unable to provide the same level of public health and safety protection as larger systems due to a lack of economy of scale and the difficulty in finding certified operators to assist them. Their capacity for financial management is critical, including training of water commissioners and understanding how to charge the true cost of water to customers. They also need technical assistance and managerial capacity to help deal with complex Safe Drinking Water Act regulations and critical drinking water operations. Where possible, regionalization is one option to assist small communities in meeting their obligations. Another option is to assist them through funding and technical assistance to develop better technical, financial, and management capabilities. Drinking Water State Revolving Funds should be made more accessible for small systems.

8.4.3 Maintain and Upgrade Drinking Water Infrastructure

As treatment facilities, water tanks, pumps, and water mains age, their tendency to fail increases, sometimes dramatically. However, few water systems, even the largest, can afford to pay for all of the capital improvements required to get their systems up-to-date. A significantly greater funding level is needed to protect public health and safety; the long-term economic and public health costs of not upgrading the infrastructure are too great.

8.4.4 Improve Local Protection Efforts

Although the state provides siting criteria for certain potential contamination sources, such as above ground and underground storage tanks and landfills, local planning and zoning boards have a much greater role in restricting the siting of activities that present a risk of contamination. Municipal governments need to improve their capacity to protect their own water supplies from the negative impacts that can result from development (see description of landscape change in Chapter 1 – Introduction and Overview). In addition to water wise local ordinances, more permanent protection of critical water supply lands through conservation is needed. Finally, in lieu of a statewide approach to ensure private wells are tested, municipalities should be encouraged to adopt ordinances to ensure that well testing and disclosure is occurring.

8.4.5 Track Emerging Contaminants

Although the provision of drinking water is already highly regulated, new contaminants and po-tential contaminants are identified every day. For example, using MTBE (Methyl tertiary-Butyl Ether) in gasoline to improve air quality turned out to be a mistake from the standpoint of groundwater protection, and this highly soluble contaminant has been found in many areas of New Hampshire (Ayotte et al., 2008). Although MTBE is no longer used in New Hampshire, other contaminants may threaten our drinking water quality in the future. For example, pharmaceuticals and personal care products are now being found at trace levels in groundwater and surface water in many parts of the country. Whether these will be found in New Hampshire, whether they will have human health effects, and the extent of their ecological effects, remain to be seen, but New Hampshire must continue to track research and health assessments to make sure that appropriate water quality health standards are developed when needed.

8.4.6 Water System Security and Interconnection

The water sector continues to be a concern as a target for terrorism. Preparedness for natural disasters is also necessary. DES and EPA have provided funding to help harden public water systems and to promote emergency interconnections between municipal systems. The state also encourages public water systems to join New Hampshire's Public Works Mutual Aid Program so that water systems can assist one another in the event of an emergency by enabling a prompt and effective response. Although emergency plans are required for community water systems, more emphasis in emergency preparedness is necessary including improved communications and coordination with local first responders and funding for backup power.

8.4.7 Prepare for Climate Change

Water systems need to understand climate change (see Chapter 1 – Introduction and Overview) and prepare adaptation strategies. The state should assist with identifying the anticipated impact of future climate change for the state's large, municipal water systems. The Drinking Water State Revolving Loan Fund program should take this information into consideration when making infrastructure investment decisions. It should also address drinking water impacts overall in future versions of the New Hampshire Climate Change Action Plan (NHDES, 2008b).

References

American Water Works Association. (2008). *Drinktap.org*. Retrieved March 14, 2008. Available at: www.drinktap.org.

Apte, M.G., Price, P.N., Nero, A.V., & Revzan, K.L. (1999). Predicting New Hampshire indoor radon concentrations from geologic information and other covariates. *Environmental Geology*, 37(3), 181-194.

Ayotte, J.D., Argue, D.M., McGarry, F.J., Degnan, J.R., Hayes, L., Flanagan, S.M., & Helsel, D.R. (2008). Methyl tert-Butyl Ether (MTBE) in public and private wells in New Hampshire: occurrence, factors, and possible implications. *Environmental Science and Technology, 42*(3), 677-684. Available at: http://pubs.acs.org/cgi-bin/sample.cgi/esthag/2008/42/i03/pdf/es071519z.pdf.

Ayotte, J.D., Baris, D., Cantor, K.P., Colt, J., Robinson, G.R., Jr., Lubin, J.H., Karagas, M., Hoover, R.N., Fraumeni, J.F., Jr., & Silverman, D.T. (2006a). Bladder cancer mortality and private well use in New England: An ecological study. *Journal of Epidemiology and Community Health, 60,* 168-172.

Ayotte, J.D., Nolan, B.T., Nuckols, J. R., Cantor, K.P., Robinson, G.R., Jr., Baris, D., Hayes, L., Karagas, M., Bress, W., Silverman, D.T., & Lubin, J.H. (2006b). Modeling the probability of arsenic in groundwater in New England as a tool for exposure assessment. *Environmental Science and Technology, 40*(11), 3578 – 3585.

Curriero, F.C., Patz, J.A., Rose, J.B., & Lele, S. (2001). The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948-1994. *American Journal of Public Health, 91,* 1194-1199.

Horn, M.A., Moore, R.B., Hayes, L., & Flanagan, S.M. (2008). *Methods for and estimates of 2003 and projected water use in the Seacoast Region, southeastern New Hampshire* (U.S. Geological Survey Scientific Investigations Report 2007-5157.). Available at: http://pubs.usgs.gov/sir/2007/5157/.

Kendall, P. (1991). Drinking water quality and health. *Service in Action, 9.307.* Fort Collins, Colo.: Colorado State University Cooperative Extension. Available at: http://www.cdc.gov/nasd/docs/d0-00001-d000100/d000009/d000009.pdf.

Messner, M., Shaw, S., Regli, S., Rotert, K., & Blank, V. (2006). An approach for developing a national estimate of waterborne disease due to drinking water and a national estimate model application. *Journal of Water and Health, 4*(2), 201-240.

Moore, R.B. (2004). *Quality of water in the fractured-bedrock aquifer of New Hampshire* (U.S. Geologic Survey Scientific Investigations Report 2004-5093).

New Hampshire Department of Environmental Services. (2005). *Radon in air and water: An overview for the homeowner* (fact sheet WD-WSEB-3-12). Available at: http://des.nh.gov/organization/commissioner/pip/factsheets/dwgb/documents/dwgb-3-12.pdf.

New Hampshire Department of Environmental Services & New Hampshire Office of Energy and Planning. (2006). Model groundwater protection ordinance (WD-06-41). Available at: http://des.nh.gov/organization/commissioner/pip/publications/wd/documents/wd-06-41.pdf.

New Hampshire Department of Environmental Services. (2008a). *Annual compliance on public water system violations, January 1, 2007-December 31, 2007* (NHDES-R-WD-08-10). Available at: http://des.nh.gov/organization/divisions/water/dwgb/documents/2007_annual_complicance_report.pdf.

New Hampshire Department of Environmental Services. (2008b). Climate Change Policy Task Force. Retrieved December 8, 2008 from NHDES Web site. Available at: http://des.nh.gov/organization/divisions/air/tsb/tps/climate/action_plan/index.htm.

New Hampshire Department of Environmental Services. (2008c). New Hampshire Geological Survey and Drinking Water and Groundwater Bureau. Unpublished data.

New Hampshire Department of Environmental Services. (2008d). One Stop data and information. Retrieved December 8, 2008 from NHDES One Stop Web site. Available at: http://www2.des.state.nh.us/OneStop/.

New Hampshire Department of Environmental Services. (2008e). Private Well Testing Program. Retrieved December 8, 2008 from NHDES Web site. Available at: http://des.nh.gov/organization/divisions/water/dwgb/dwspp/index.htm.

Robinson, G.R., Jr., & Ayotte, J.D. (2006). The influence of geology and land use on arsenic in stream sediments and ground waters in New England, USA. *Applied Geochemistry, 21,* 1482-1497.

Rocha-Amador, D., Navarro, M.E., Carrizales, L., Morales, R., & Calderon, J. (2007). Decreased intelligence in children and exposure to fluoride and arsenic in drinking water. *Cadernos de Saude Publica* (Reports in Public Health), *23*(S4), S579-87.

Rural Community Assistance Partnership. (n.d.). *Still living without the basics in the 21st Century: Analyzing the availability of water and sanitation services in the United States.* http://rcap.org/assets/docs/basics/RCAP_full_final.pdf.

U.S. Environmental Protection Agency. (September 2003). *Small systems guide to Safe Drinking Water Act regulations* (EPA 816-R-03-017). Available at: http://www.epa.gov/ogwdw/smallsystems/pdfs/guide_smallsystems_sdwa.pdf.

U.S. Environmental Protection Agency. (2005). *Drinking water infrastructure needs survey and assessment, Third Report to Congress* (EPA 816-R-05-001). Available at: http://www.epa.gov/safewater/needssurvey/pdfs/2003/report_needssurvey_2003.pdf.

U.S. Environmental Protection Agency. (2008a). *Progress in providing safe drinking water.* Retrieved April 16, 2008 from EPA Web site. Available at: http://www.epa.gov/OGWDW/sdwa/30th/article_progress.html.

U.S. Environmental Protection Agency. (2008b). *Why water efficiency?* Retrieved March 28, 2008, from EPA Web site. Available at: http://www.epa.gov/WaterSense/water/why.htm.

Virginia Department of Health. (2007). *Source water protection in Virginia.* Retrieved July 15, 2008 from VDH Web site. Available at: http://www.vdh.virginia.gov/drinkingwater/source/importance.htm?mode=printable.