Arsenic Contamination in Vermont's Private Wells

An Analysis of Geographic Distribution, Public Awareness and Policy

Middlebury College
Environmental Studies Senior Seminar
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Led by:
Peter Ryan
Diane Munroe

Community Partners:
Vermont Geological Survey: Jon Kim, Larry Becker, Marjorie Gale
Vermont Department of Health: Joanne Calvi
Senator Virginia Lyons

Class Members:
Meghan Blumstein
Ashley Cheung
Carson Cornbrooks
James Hexter
Renee Igo
Marc Kostrubiak
Pier LaFarge
Jia (CoCo) Liu
Kelly March
Marilyn Mead
Michaela O'Connor
Rachel Pentecost
Virginia Shannon
Sarah Simonds
Kelly Slentz
Nicole Vaughan
Zheng Zheng

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Abstract

The Environmental Studies Senior Seminar (ENVS 401) is the capstone course for the Environmental Studies major. The goal of this course is to bring seniors from the various foci within the Environmental Studies major together to examine a specific topic in depth from an interdisciplinary perspective. The course follows a service-learning teaching model, which combines collaborative work with a community organization, scholarly reading, classroom discussions, and reflective writing. Topics of ENVS 401 vary from semester to semester, but focus on issues with relevance to the local region as well as the global environment. Our theme for this semester was "The Groundwater Resource: Global Concerns, Local Perspectives."

The class split into three groups: the survey group, partnering with the Vermont Department of Health; the spatial group, partnering with the Vermont Geological Survey; and the policy group, partnering with State Senator Virginia Lyons. The goal of the survey group was to evaluate the public's knowledge of their well water and testing recommendations in a study area in Rutland County. The goal of the spatial group was to investigate the incidence of high arsenic well test results and the relationship between bedrock and high arsenic to locate areas of concern in Vermont. The goal of the policy group was to provide our community partner with information pertinent to advancing the policy discussion regarding private well testing regulations in Vermont. We used our research to create a policy framework that the legislature can work off of in the 2010-2011 legislative season.

Introduction

I. Narrative Story – Bjorn

During the first week of our ENVS401 Senior Seminar, we visited a family in Whiting, Vermont to hear the story of Bjorn, a five-year-old boy who had suffered from arsenic poisoning due to drinking water from a well with elevated arsenic. Bjorn lived with his parents in Cornwall until the age of three when his family moved three miles down the road to his grandparents' house in Whiting. Shortly after moving into his new home in November 2008, Bjorn started having serious behavioral problems and showed signs of health issues including a rash and stomach discomfort. As weeks passed Bjorn's health continued to deteriorate. He was vomiting, had frequent diarrhea, was disoriented, lethargic, pale and dehydrated. He had become dull and quiet, was visibly fatigued, and refused to eat. Bjorn's parents took him to the doctor after he started becoming violently ill for up to five days at a time. The doctor began blood tests to try to understand what was happening.

Over the next three months, Bjorn also faced developmental issues. Along with his illness it appeared that he was actually regressing developmentally. He stopped dressing himself, climbing and hopping, asking questions and joking around. His former loquaciousness was replaced with fragmented, failed attempts to speak. Bjorn's general behavior became atypical of his usually cheerful and inquisitive personality. He started seeming disoriented, never wanted to go anywhere, and had little energy to show interest or joy.

In December, Bjorn's parents began to notice that their three-year-old son seemed much more alert and active when they took trips away from home; however, he became sick again each time they returned to Whiting. At this point Bjorn's parents started looking for environmental causes. They tested the drinking water from their private well but found no elements above the EPA limits. After taking a closer look at the drinking water they noted that the only contaminant that tested even slightly high in the water test was arsenic. At 6 parts per billion (ppb), it was below the EPA standard for safe drinking water (for public water supplies) of 10 ppb, but Bjorn's parents learned that the EPA had originally proposed 5 ppb for a safer standard, and the Natural Resources Defense

Council recommended 3 ppb (“Arsenic Rule,” EPA). Their private well water was retested in January 2009 and the arsenic was measured at 14 ppb. Although this level of arsenic is not expected to render someone as seriously ill as Bjorn had become, his parents decided to take him off well water to see if it helped his recovery.

After only two days of switching to bottled water Bjorn started to feel better. He started walking again and became more cheerful but was still confused, disoriented, and quiet. By the third day, Bjorn seemed more like himself than he had since November. He was hungry, talked, joked, ran, and laughed. By the fifth day, Bjorn started dressing himself and climbing again. In subsequent weeks he regained his physical stamina and energy level.

However, after seven weeks on bottled water, Bjorn’s parents were distraught to see that their son had not fully recovered and were still confused about the cause of his illness. They brought him to the Pediatric Environmental Health Clinic at Children’s Hospital in Boston where doctors concluded that it was arsenic poisoning that had caused the decreased developmental milestones. Medical professionals predicted it would take a few months to see how complete Bjorn’s recovery would be.

After learning of the elevated arsenic in their water, Bjorn’s grandparents had an under-the-sink reverse osmosis system installed to remove the arsenic from their drinking water. Five months after his recovery began Bjorn had the same physical and mental abilities that he had before he became sick. His parents are now immersing him in a rich learning environment to help him catch up after losing eight months of developmental progress. While this is just an anecdotal account of an individual child’s response to elevated arsenic, it does show the importance of being informed about private well drinking water.

II. Health Effects

Because aqueous arsenic is clear and odorless, people may unknowingly consume arsenic in their drinking water and suffer from serious—sometimes irreversible—health problems. Symptoms of arsenic poisoning can range from thickening and discoloration of skin, digestive problems, and numbness in hands and feet to various types of cancer (Illinois Department of Health). As seen in Bjorn’s story, low-level exposure symptoms such as digestive problems can be difficult to link to arsenic and may go unnoticed. Studies on health effects of arsenic exposure have been done in countries where the local population is dependent on groundwater that has particularly high concentrations of arsenic. These studies found that long-term exposure to arsenic in groundwater significantly raises the risk of mortality due to lung, bladder, and skin cancers (Smith et al., 2000). In addition to its designation as a Group 1 carcinogen, chronic arsenic poisoning (arsenicosis) has been linked to hyper- and hypo- skin pigmentation, skin lesions, hypertension, cardiovascular disease, respiratory disease, and diabetes (Howard, 2003; Ng et al., 2003).

It is likely that children are more susceptible to low arsenic exposure as studies have shown children to experience serious symptoms from low-level exposure to other toxins such as nitrites from herbicide run-off into surface and groundwater. In 2009 the American Academy of Pediatrics published an article on drinking water and contamination effects on children. The authors noted a study of 235 rural household in Canada using well water. The study found that the "odds of a child younger than 10 years having an episode of gastrointestinal illness, given the presence of at least 5 colony-forming units of *Escherichia coli* in the water, was 4.2 times higher than that for adults older than 50 years" (Rogan et al, 2009).

III. Geology

Arsenic is an element that occurs naturally in bedrock and soil. In the United States, it has been reported to be a common well water contaminant in Maine, parts of North Carolina, Alaska, and parts of the western US (Rogan et al, 2009). Arsenic dissolves into water through natural weathering as underground water flows through rocks or soil that contain the element. Arsenic occurs in a variety of minerals but it is most commonly found in sulfide minerals such as pyrite and arsenopyrite, and in iron hydroxides (Smedley and Kinniburgh, 2002). Arsenic has also been found to occur in silicate minerals such as antigorite (Hattori et al., 2005), smectite (Pascua et al., 2005), and garnet (Charnock et al., 2007). In central New Hampshire elevated arsenic levels in groundwater from bedrock wells have been attributed to the post-tectonic partitioning of arsenic into plutons, pegmatites, and metasedimentary rocks, particularly the minerals arsenopyrite and scorodite (Peters and Blum, 2003).

In the spring of 2005, arsenic concentrations of 90 and 327 ppb were found in private bedrock-sourced drinking-water wells in the Waterbury-Stowe area of north central Vermont (Bright, 2006). Recent Middlebury College geology theses (Bright, 2006; Sullivan, 2007; Chow, 2009) have identified ultramafic rocks as a likely source of arsenic in the bedrock aquifer within the Rowe-Hawley Belt (RHB) near Stowe, Vermont. Several public and private wells in Troy, Newport and Coventry, Vermont produce groundwater with arsenic concentrations that consistently exceed the EPA Maximum Contamination Level and range from 0 to 113 ppb, thus posing significant health concerns for residents relying on this aquifer (Corenthal, 2010). During her thesis work, Lilly Corenthal verified a correlation between ultramafic rocks and elevated arsenic in derived surficial sediments through a combined spatial, mineralogical and geochemical analysis of sites in Troy, VT (Corenthal, 2010).

A study conducted in 2010 titled *Elevated Arsenic in Domestic Wells from the Taconic Allochthons in Southern Vermont* found that 42% of private bedrock wells tested thus far in the town of Castleton, Poultney and Wells contain arsenic levels exceeding 10 ppb with an average concentration of 30 ppb (Clark et al., 2010). Farther to the south in Pawlet and Rupert, 13% of private wells tested thus far contain levels exceeding 10 ppb arsenic (Mango, 2009). The study concluded that these findings suggest spatial (or possibly temporal) variability in aquifer hydrochemistry (Clark et al, 2010). Mango (2009) and Clark et al. (2010) also made several other conclusions concerning the origin and geochemical behavior of arsenic in the Taconics. According to their research, the ground water geochemistry indicates positive correlations of arsenic and sulfate, and arsenic and iron, which indicates that pyrite is the arsenic source. Elevated arsenic in the pyrite (up to 993 mg/kg) further confirms that the dissolution of pyrite is the primary arsenic source. The authors believe that once iron, arsenic, and sulfate are released into the water by oxidation of pyrite, ion exchange is an important control on ground water chemistry. According to the authors, very high concentrations of sodium observed in this study are common in shales and slates where sodium is released from exchange sites. The study also found that arsenic only appears to exceed 10 ppb in waters that are relatively reducing (Clark et al., 2010). Ideally, the ENVS 401 spatial group will provide valuable information on the relationship between bedrock and arsenic, helping to locate rock types and geographical areas of concern in Vermont.

IV. EPA Requirements and Lack of Comprehensive Policy for Private Wells

The Safe Drinking Water Act (SDWA) is the main federal law that ensures the quality of Americans' drinking water. Congress originally passed the SDWA in 1974 to protect public health, and amended it in 1986 and 1996. Under the SDWA, the United States Environmental Protection Agency sets standards for drinking water quality, and oversees states, localities, and water suppliers who implement these standards.

The EPA has created a set of National Primary Drinking Water Regulations (NPDWRs or primary standards), which are legally enforceable standards that apply to public water systems. Primary standards protect public health by limiting the levels of contaminants in municipal drinking water. Regulated contaminants include microorganisms, disinfection byproducts, disinfectants, organic chemicals, radionuclides, and inorganic chemicals such as antimony, arsenic, asbestos, barium, beryllium, cadmium, chromium, copper, cyanide, fluoride, lead, mercury, nitrate, nitrite, selenium, and thallium. The EPA has also created a set of National Secondary Drinking Water Regulations (NSDWRs or secondary standards), which are non-enforceable guidelines regulating contaminants that may cause cosmetic effects such as skin or tooth discoloration, or aesthetic effects such as taste, odor, or color in drinking water. The EPA recommends these standards to municipal water systems but does not require systems to comply ("Drinking Water Contaminants," EPA).

There are no enforceable EPA standards for private wells, which are common sources of drinking water in rural areas. This is especially a problem in Vermont where the Vermont Department of Health estimates that 40% of state residents use private groundwater wells for their drinking water. Currently the Vermont Department of Health has testing recommendations for private wells in Vermont, but public knowledge about the pervasive problem of groundwater contamination by arsenic and other chemicals is limited. As a result, there is a low rate of adherence to these guidelines. The VDH recommends the following testing schedule for private wells:

- Total coliform bacteria test: every year
- Inorganic chemical test: every five years
- Gross alpha radiation screening test: every five years

A total coliform bacteria test is called Kit A. Coliform bacteria are a large group of soil and intestinal bacteria that indicate potential well contamination that could cause health problems. If total coliform bacteria are found, the water is then checked to determine if the origin of the contamination is fecal. Boiling drinking water for one minute will kill bacteria so that it can be used for drinking. The inorganic chemical test, known as Kit C, tests for arsenic, chloride, copper, fluoride, hardness, iron, lead, manganese, nitrate, sodium, and uranium. Many of these inorganic chemicals (arsenic, fluoride, lead, manganese, and uranium) can cause health problems. The gross alpha radiation test is known as Kit RA, and it is a screening test for mineral radioactivity in water derived from elements such as uranium and radium. While water usually has some radioactivity, the gross alpha test helps determine if the levels are high enough to warrant additional testing due to potential health concerns ("Testing Your Water Supply," VDH website).

There is an overall gap in information on arsenic in Vermont private wells. Our hope for the survey group, spatial group, and policy group is to provide our community partners a framework for gathering more information on arsenic, educating the public, and managing private well testing. The following report synthesizes our work this semester on arsenic contamination in private wells in Vermont.

Chapter 1: Spatial Group

Introduction

The spatial group collaborated with community partners at the Vermont Geological Survey (VGS) to assess the spatial distribution of arsenic occurrence in Vermont. The VGS became concerned with arsenic after several reports of high test results from public and private groundwater supplies were shared by the Vermont Department of Health (VDH). By mapping high test results, the VGS noticed patterns of high arsenic in certain bedrock types but required more data. At the onset of this project, there was thorough data on public water supplies but little data on private well testing. The VGS had various datasets on private well testing but there was a need to synthesize the data into a comprehensive dataset. There was also a need to analyze the data to describe arsenic occurrence in Vermont and predict areas of concern for residents. Data analysis is also crucial to inform health education and policy decisions.

Goals of Spatial Analysis

- Aggregate all available data for arsenic testing of private wells into a comprehensive dataset
- Record methodology for our work to be followed as new data become available
- Identify risk areas for high arsenic levels in private groundwater wells
- Examine relationship between bedrock geology and occurrence of high arsenic levels
- Produce visual representations of the arsenic problem in Vermont for education and policy purposes

Methods

Data management:

We started with five data sets from the Vermont Geological Survey. We supplemented these files with open-access web sources as well as excel data from the VDH.

- Vermont Department of Health – data recorded by Kit C tests from homeowner sampling of private well water
- Additional Kit C – data recorded from all Kit C tests from 2004 to present from homeowner sampling of private well water
- Vermont Water Supply Division – data recorded from mandated, annual public water supply water testing
- Helen Mango, Professor of Geology, Castleton State College – data collected for a study of naturally occurring arsenic (Mango, 2009).
- Independent project by Middlebury College students Arthur Clark and Taylor Smith, advised by Peter Ryan, Professor of Geology and Environmental Studies – data collected for a study of naturally occurring arsenic (Clark et al., 2010).

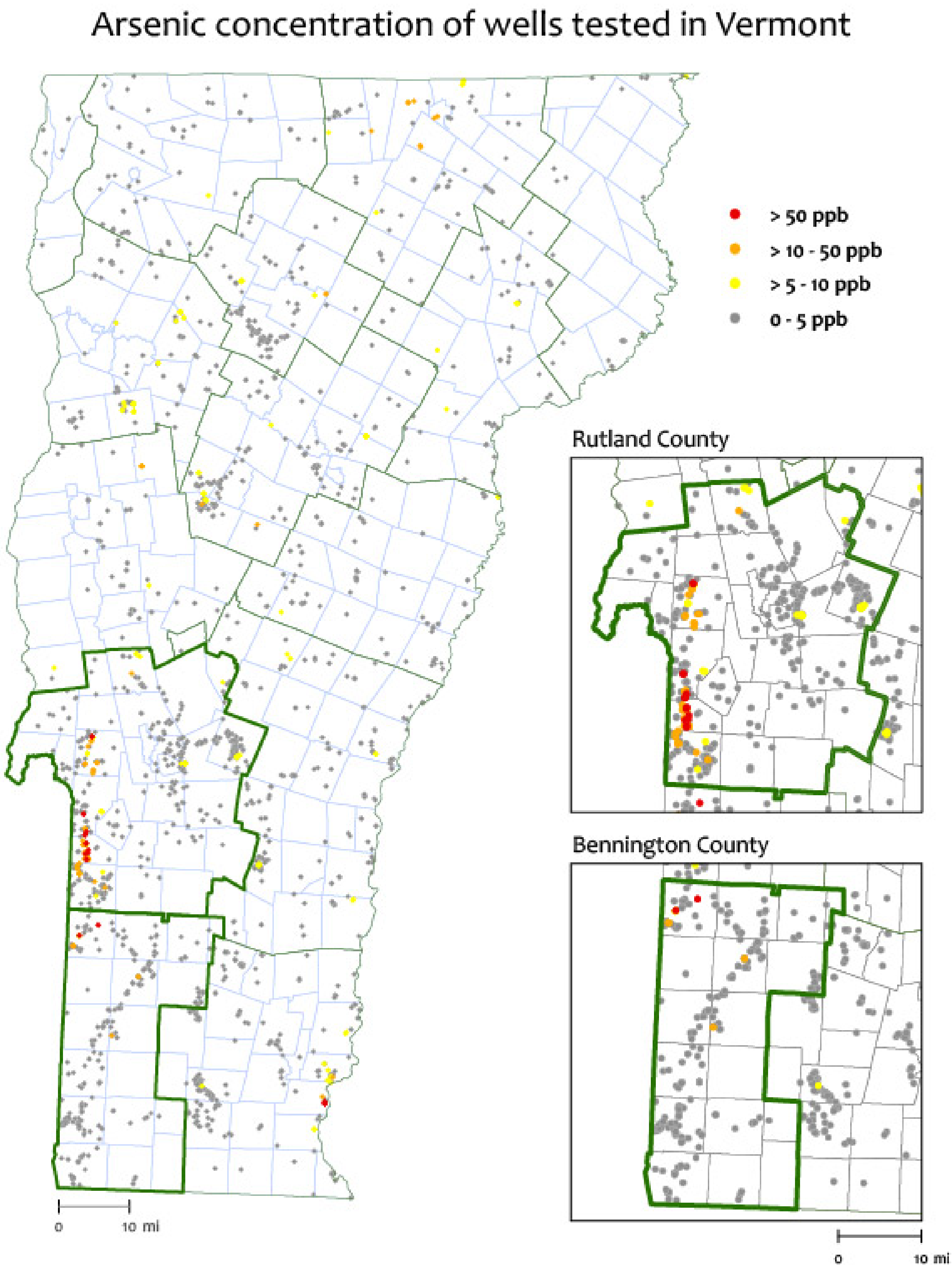
We first merged the five original well testing datasets into a single layer and placed it in a geodatabase. As we were given additional information we added it to the original merged layer. Throughout the process we controlled for repeat data points that occurred as we merged these datasets. We found many Kit C tests were associated with P.O. boxes that could not be spatially referenced to well locations; thus, all P.O. boxes were excluded from data analysis because the wells associated with these points could not be accurately located. In collecting and joining all of these datasets we have created the most comprehensive dataset of arsenic tests for private wells in Vermont.

Analysis:

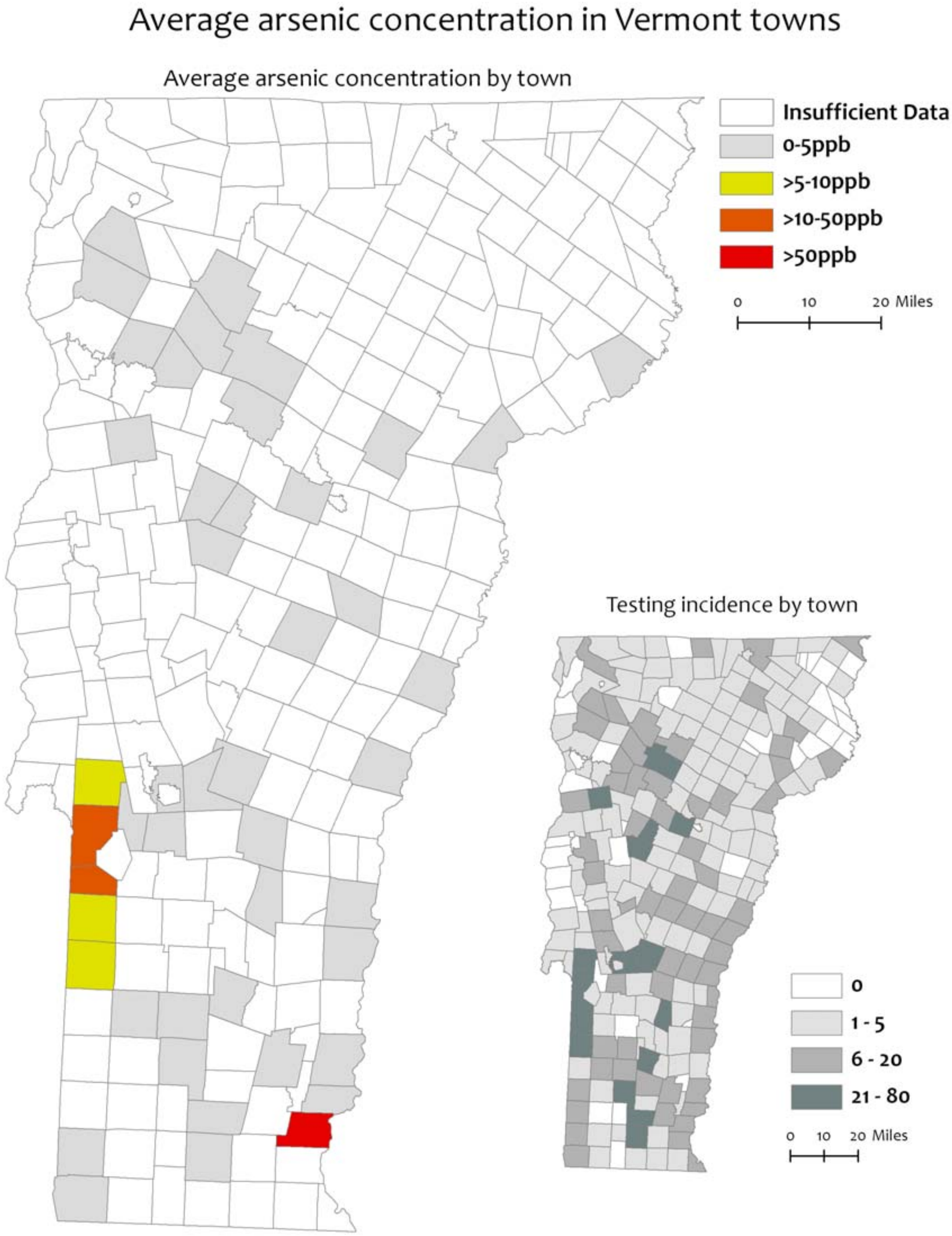
Using the complete private well testing geodatabase, we directed our analysis to two main foci: testing incidence and relationship of arsenic in well water to bedrock geology. For all analyses we used ArcGIS 10.0. Testing incidence analysis consisted of overlaying well test sites onto town and county maps in Vermont. Average arsenic levels from well water tests reported in each town were calculated to identify potential towns of concern. Bedrock geology analysis located arsenic levels in wells producing from different bedrock types using a vector of Vermont bedrock. We calculated the percent of wells found at greater than 5 ppb, greater than 10 ppb, and greater than 50 ppb in each bedrock type. Due to previous VGS concern with elevated arsenic in the Taconic Allochthons in southwestern Vermont, we focused further analysis on Rutland and Bennington counties.

Results

High arsenic levels were found in small pockets throughout the state (Map 1-1). The most notable collection of high arsenic results were in Rutland and Bennington counties. These two counties had the greatest number of high arsenic results and also the highest test incidence. In addition to Rutland and Bennington counties, arsenic tests of greater than 50 ppb were also recorded in Orleans and Windham counties. A majority of towns lacked enough tests ($\geq$ 10 tests) to be able to draw conclusions about arsenic (Map 1-2). Wells producing groundwater from bedrock category 3, which includes locally graphitic slate, greywacke, and conglomerate (the rock types commonly found in the Taconic range) had the highest average arsenic concentration of 11.3 ppb (n=314 tests) (Map 1-6). Overall, Vermont had an average arsenic concentration in wells of 3.2 ppb (Table 1-1). Wells located in the Taconic Allochthons had an average arsenic concentration of 11.1 ppb, nearly four times the state average (Table 1-1). Within the Taconic Allochthons, there also appears to be variation in groundwater arsenic as a function of rock formation (Table 1-2), where the St. Catherine (Csc) and Pawlet (Opa) formations each have average well-water arsenic concentrations of ~14 ppb. The other formations all have average values $\leq$ 5 ppb.

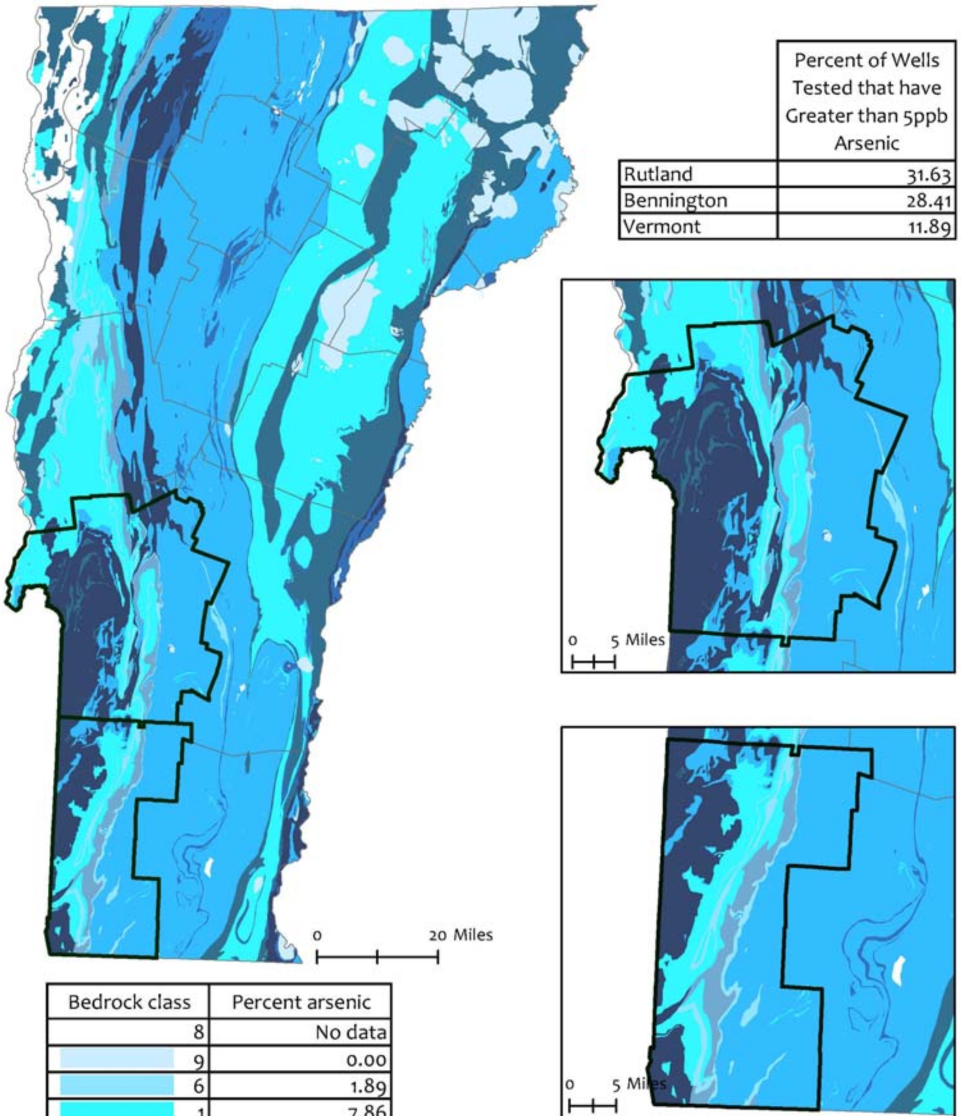


Map 1-1. The incidence of arsenic in private wells in Vermont. This dataset is the most comprehensive private well testing data available. Pockets of high arsenic concentrations can be seen around the state. Of major concern are the values in Bennington and Rutland counties, which have been more thoroughly tested compared to other regions of the state. Pockets are also seen in Orleans (north-central VT) and Windham (southeastern VT) counties.



Map 1-2. Average arsenic concentration in Vermont by town. Towns with less than 10 tests were excluded from analysis. This analysis shows that towns in western Rutland and northwestern Bennington counties have high average arsenic concentrations. There is a clear need for more testing to be done so that arsenic distribution can be better understood.

Percent of wells greater than 5 ppb arsenic in Vermont

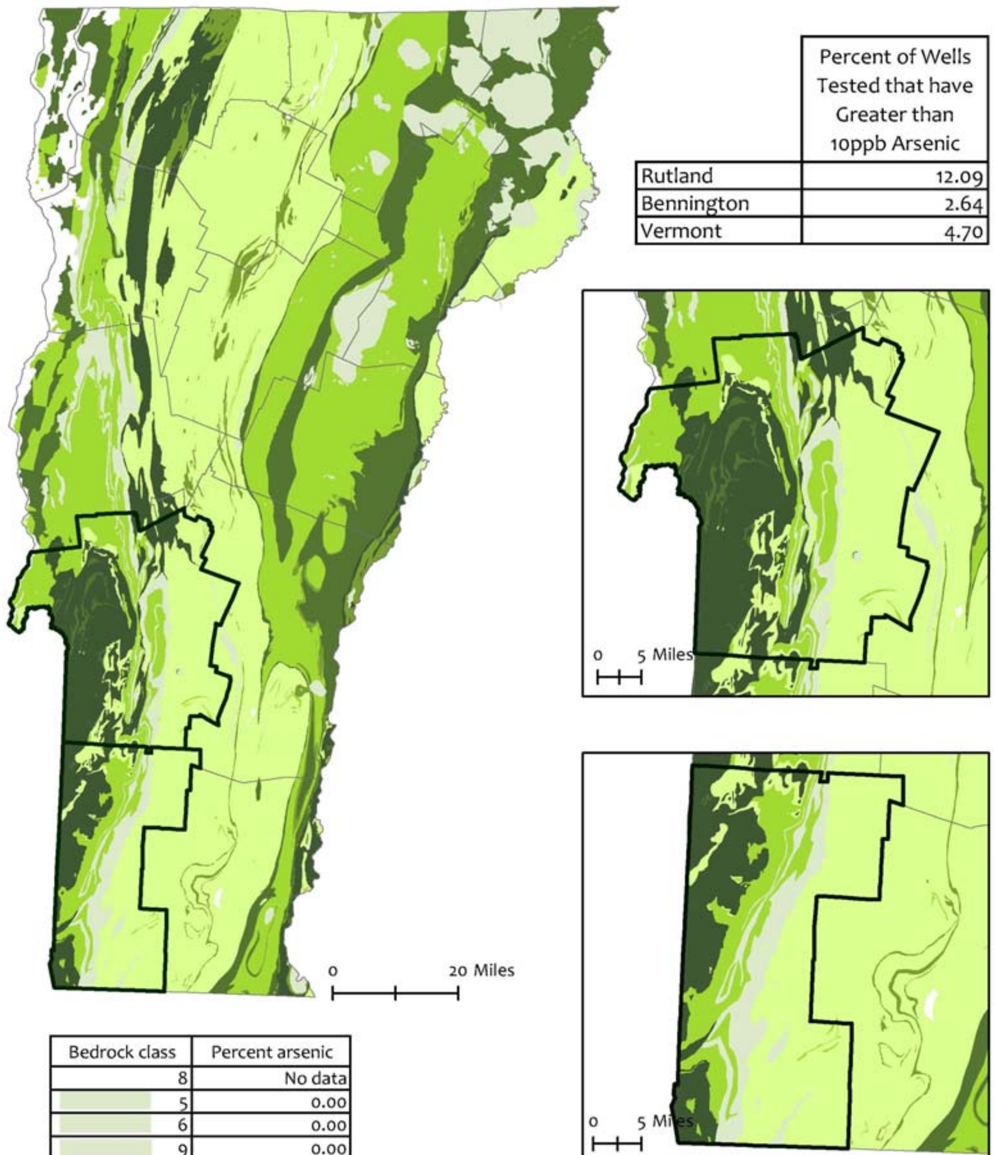


	Percent of Wells Tested that have Greater than 5ppb Arsenic
Rutland	31.63
Bennington	28.41
Vermont	11.89

Bedrock class	Percent arsenic
8	No data
9	0.00
6	1.89
1	7.86
4	9.08
5	11.90
7	13.56
2	14.10
3	25.16

Map 1-3. Bedrock correlations showing the percent of wells with arsenic levels greater than 5 ppb. In several of the different rock types, more than 10% of wells have arsenic above 5 ppb. Bedrock category 3 is of particular concern, as over 25% of wells dug in it have arsenic levels above 5 ppb. Nearly 12% of wells in all of Vermont have arsenic levels above 5 ppb. Around 30% of wells in Bennington and Rutland counties have levels above 5 ppb.

Percent of wells greater than 10 ppb arsenic in Vermont

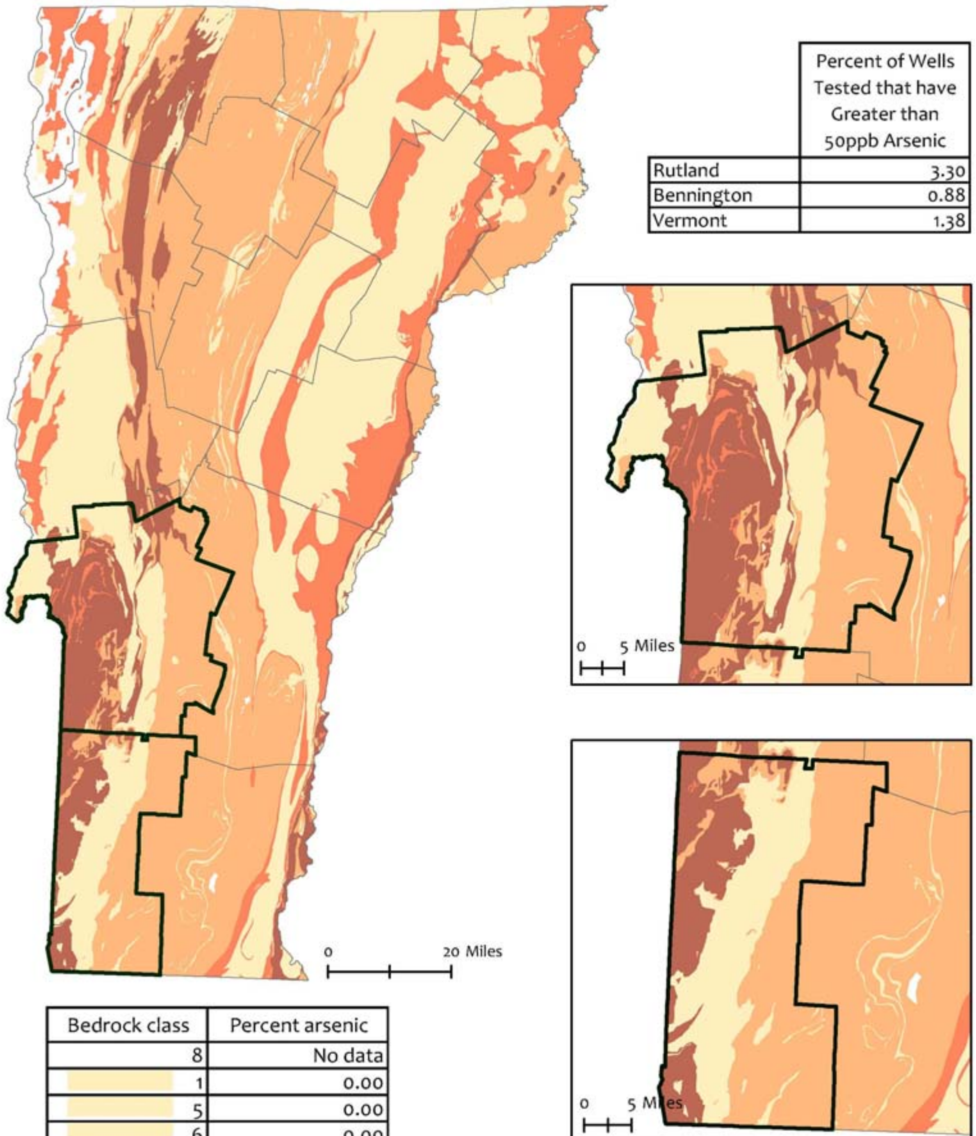


	Percent of Wells Tested that have Greater than 10ppb Arsenic
Rutland	12.09
Bennington	2.64
Vermont	4.70

Bedrock class	Percent arsenic
8	No data
5	0.00
6	0.00
9	0.00
4	0.67
1	2.46
7	5.08
2	6.14
3	18.15

Map 1-4. Bedrock correlations showing the percent of wells with arsenic levels greater than 10 ppb. Over 18% of wells in bedrock class 3 had arsenic concentrations of greater than 10 ppb.   Nearly 5% of wells in all of Vermont have arsenic levels above 10 ppb, while over 12% of all wells in Rutland County have arsenic concentrations above 10 ppb.

Percent of wells greater than 50 ppb arsenic in Vermont

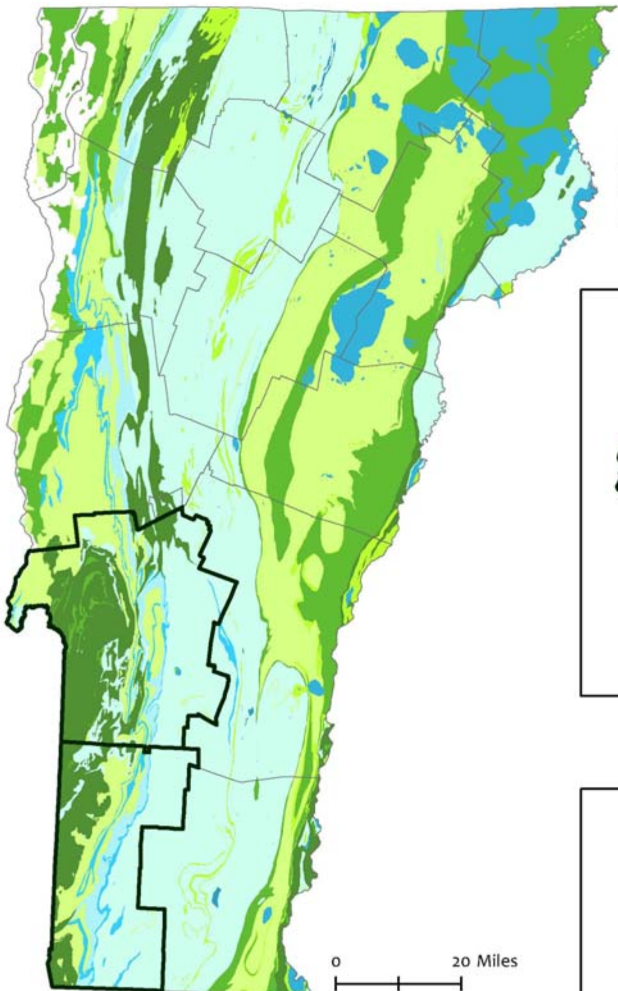


	Percent of Wells Tested that have Greater than 50ppb Arsenic
Rutland	3.30
Bennington	0.88
Vermont	1.38

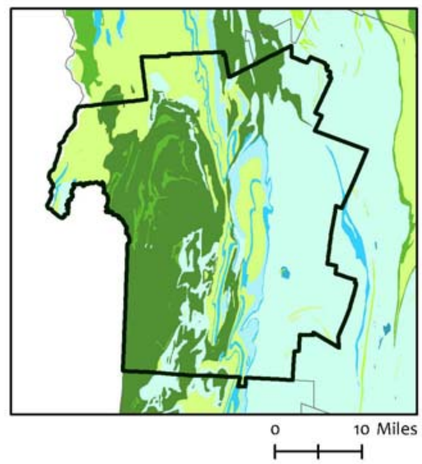
Bedrock class	Percent arsenic
8	No data
1	0.00
5	0.00
6	0.00
7	0.00
9	0.00
4	0.13
2	3.21
3	6.05

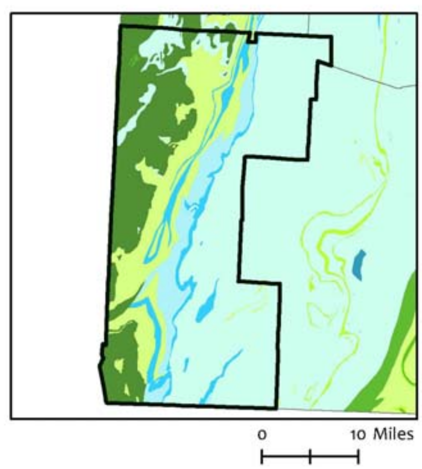
Map 1-5. Bedrock correlations showing the percent of wells with arsenic levels greater than 50 ppb. Over 6% of wells in bedrock class 3 had arsenic concentrations of greater than 10 ppb. 1.4% of wells in all of Vermont have arsenic levels above 50 ppb, while 3.3% of all wells in Rutland County have arsenic concentrations above 50 ppb.

Average arsenic concentration in Vermont wells



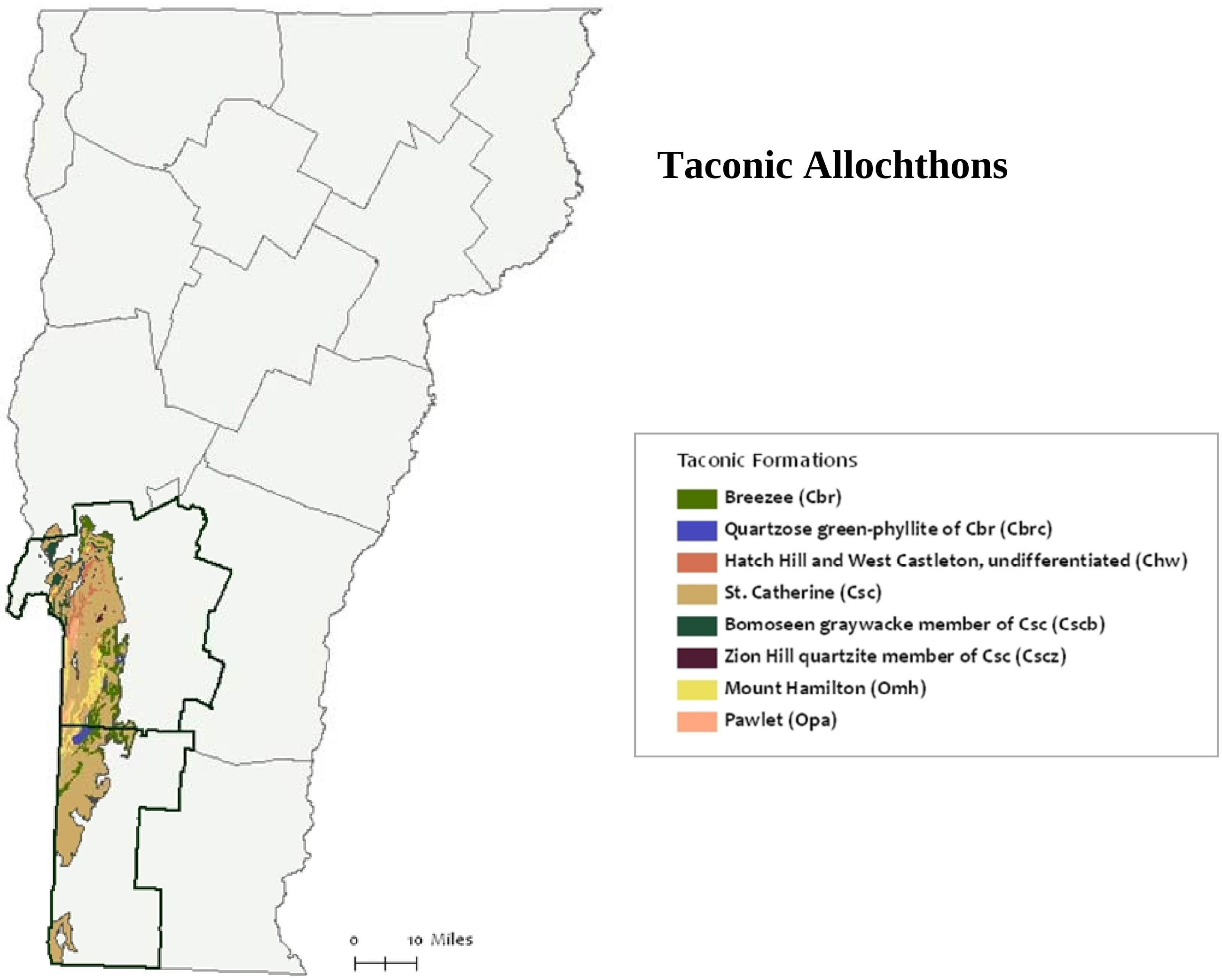
	Average arsenic level in wells (ppb)
Rutland	6.17
Bennington	1.19
Vermont	2.43





Bedrock class	Average arsenic (ppb)	Number of tests
1	1.014	407
2	5.595	156
3	11.333	314
4	0.994	749
5	0.881	42
6	0.302	53
7	1.508	59
8	No data	0
9	0.282	28

Map 1-6. Average arsenic concentrations in bedrock types across Vermont. Bedrock class 3 yielded tests with an average arsenic concentration of over 11 ppb, and has been thoroughly tested in some areas of the state. The average arsenic concentration in all bedrock types across the state is 2.4 ppb, while the average concentration in Rutland County is 6.2 ppb. Some bedrock classes lack sufficient testing. Of important note is the fact that, while two separate sections of bedrock may belong to the same category, they may have different chemical composition. This is due to the fact that different pockets of bedrock across the state formed at different times and under different conditions.



Map 1-7. The Taconic Allochthons are a sequence of slate formations thrust into their current position in Bennington and Rutland counties during the Ordovician Taconian Orogeny (Stanley and Ratcliffe, 1985). They are rocks originally deposited as deep sea clays, which contain pyrite, a naturally occurring mineral that can yield arsenic when dissolved. Within the Taconic Allochthons, Opa and Csc had the highest average arsenic concentrations of 14.0 and 14.6 ppb. The average arsenic concentration in the Taconics is 11.1 ppb, while the average concentration in the rest of Vermont excluding the Taconics is 1.8 ppb. There have been over 200 tests of private well water collected in this area, demonstrating that private wells on these formations are at high risk of containing arsenic.

Table 1-1. Incidence of arsenic in bedrock wells from Vermont (the state as a whole, and without Taconics included) compared to the Taconic region.

Regions	Wells above given As concentration (%)			Average As concentration (ppb)	Sample size
	5 ppb	10 ppb	50 ppb		
Vermont (entire state)	12	5	1	3.2	1,810
Vermont (excluding Allochthons)	9	3	< 1	1.8	1,550
Taconic Allochthons	27	21	6	11.1	260

Table 1-2. Arsenic in bedrock wells as a function of rock formation in the Taconic range.

Rock Type	Average Arsenic ppb	Incidence	Range ppb As
Cbr	4.9	18	0 - 67
Cbrc	0.9	4	.1 – 2
Chw	5.3	18	0 - 17
Csc	14.0	160	0 - 167
Cscb	1.0	4	0 - 4
Cscz	0.1	1	--
Ob	0.8	1	--
Omh	4.1	31	0 - 67
Opa	14.6	22	0 - 151

Conclusion and Recommendations

From bedrock analysis, it is clear that the Taconic Allochthons are an area of concern where every private well owner needs to test. It is important to recognize that the connection between high arsenic and the Taconic Allocthons is supported by a concentration of testing information because it is an area of interest to geologists. To ensure that all other areas of high arsenic are identified in Vermont, further testing across the state must be done.

We recommend that the geodatabase created in this project be augmented by the Vermont Geological Survey as new Kit C data and other testing information is acquired. We hope that our maps can be be used as templates to revise and represent new testing points added to the geodatabase. We found much of the data given to us from Kit C testing had P.O. Boxes listed for the well address. We discarded several data points with P.O. Box listings because we were unable to map the well location. We recommend that the VDH adopt a new Kit C form that specifies the well address and contact address separately to ensure the data can be used for geographical analysis. Continuing to build on this information will allow Vermont to make informed policy decisions and educate the public. It will also be imperative to keep communication between VGS and VDH open and continuous for data and maps to be shared to both parties for future use.

Chapter 2: Survey Group

Introduction

The Vermont Department of Health (VDH) recommends that private well owners test their water every year for bacteria, every five years for inorganic chemicals, and every five years for gross alpha radiation. However, private well water quality is unregulated, and Vermonters' awareness of and compliance with these recommendations remains uncertain. Considering the relatively small pool of existing data for inorganic chemical tests (Kit C) as outlined in the previous chapter, there may be a gap in public knowledge and concern about private water quality and naturally occurring contaminants such as arsenic. In order to address this potential education gap the VDH needs to know more about Vermonters' knowledge of private water quality issues. To this end, in collaboration with Middlebury College's Environmental Studies Senior Seminar, the VDH developed the framework for a survey to be written, conducted and analyzed by the seminar's Survey Team. The VDH requested that the survey specifically assess:

- Consumption patterns (i.e. proportion of private well owners who drink their well water)
- Private well owners' awareness of the testing recommendations
- Average frequency of well testing
- Perceived barriers to testing
- Suggestions from the public about modes of education

Our primary contact at the VDH was Joanne Calvi, Director of the VDH's Rutland District. This area of the state was the focus of our study because of the presence of the arsenic-rich Taconic Slate Belt, as discussed in the previous chapter. We focused specifically on the Rutland County towns of Castleton, Fair Haven, Pawlet, Poultney, and Wells. Interviews were conducted in person with local private well owners of these and neighboring towns, and took place in public locations, including grocery stores, local markets and election polling places.

Physicians and well drillers represent important alternative perspectives because of their direct involvement in the medical and technical sides of private well water contamination. They may also be important partners in educating the public about private water quality issues. We conducted interviews with professionals in each group, and ultimately interviewed six physicians and five well drillers.

In speaking with physicians our goals were to learn:

- What physicians know about the contamination of groundwater in their area
- Whether physicians encourage patients to test their wells
- If physicians have experience with water- and arsenic-related health issues in the area

We contacted certified well drillers to learn more about:

- Well drillers' personal awareness of arsenic and other groundwater contaminants
- Conversations that well drillers have with their clients

After learning about arsenic in drinking water and interacting extensively with local Vermonters who may be affected by this issue, we wanted to ensure that the momentum we built continues beyond our class. As a first step to meet this goal, we shared the results of our surveys with the ENVS 401 Policy Group and Vermont State Senator Virginia Lyons to guide their policy design process. Additionally, we designed a public outreach plan that will help the VDH to educate private well owners, spread awareness and encourage testing. This plan is based on recommendations from the private well owners as well as our own research on public health campaigns in other states. We hope that our recommendations will make it easier for the Vermont Department of Health to effectively educate the public on this issue.

Private Well Owners

Goal:

To survey a minimum of 100 private well owners from within the following five towns of Rutland County, VT:

- Castleton
- Fair Haven
- Pawlet
- Poultney
- Wells

Methods:

The survey (Appendix B.1, page 69) was written by our student team and finalized in collaboration with:

- Michelle McCauley, *Professor of Psychology at Middlebury College*
- Peter Ryan, *Professor of Geology and Environmental Studies at Middlebury College*
- Diane Munroe, *Coordinator for Community Based Environmental Studies*
- Joanne Calvi, *Rutland District Director for the Vermont Department of Health*
- The participants of three pilot surveys

Between October 7 and November 2, 2010 we conducted face-to-face interviews outside the following stores and events:

Table 2-1. Survey locations.

Castleton

Castleton Farmer's Market 643 Main Street Castleton, VT 05735	**Prunier's Market** 672 Route 4A Bomoseen, VT 05732 (802) 265-4516	**Gilmore Home Center** Route 4 A Bomoseen, VT 05732 (802) 468-5676	**Election Day Polling** Fine Arts Center 62 Alumni Drive Castleton, VT 05735

Fair Haven

Election Day Polling American Legion Post # 49 72 South Main Street Fair Haven, VT 05743

Pawlet

Mach's General Store VT Rt 30 & School St Pawlet, VT 05761 (802) 325-3405

Poultney

Stewart's Shops 217 Main Street Poultney, VT 05764 (802) 287-9391	**Shaw's** 55 Depot Street Poultney, VT 05764 (802) 287-4387

Wells

Wells Country Store 150 Vt Route 30 Wells, VT 05774 (802) 645-0332	**White's Trading Post** 5 Vt Route 30 Wells, VT 05774 (802) 645-0808

Ultimately, we surveyed 124 private well owners from the following towns:

Town	No. Residents Surveyed
Castleton	32
Poultney	29
Wells	16
Fair Haven	10
Pawlet	7
West Pawlet	6
East Poultney	5
Granville, NY	5
Hampton, NY	4
Middletown Springs	3
Hubbardton	2
Benson	1
Bomoseen	1
Hebron, NY	1
North Rupert	1
Rutland Town	1
n =	124

Table 2-2. Distribution of survey participants by town.

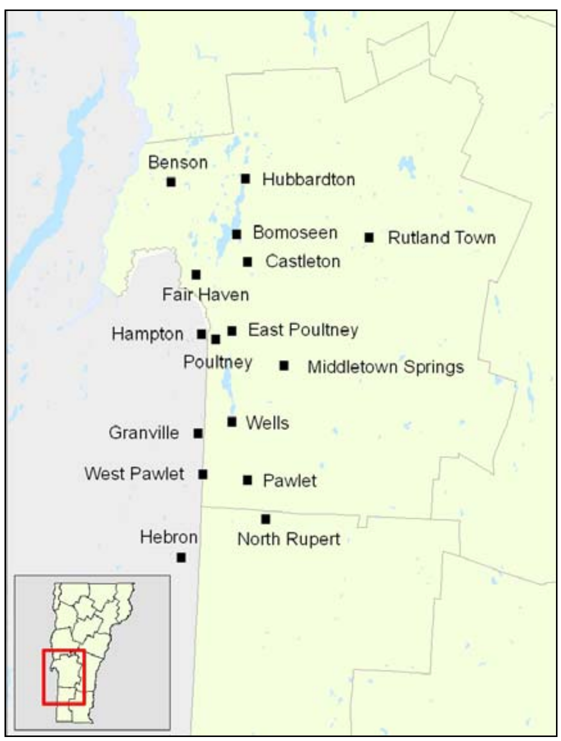


Figure 2-1. Map of Rutland County and towns with survey participants.

Our survey focused on private well water quality and testing. After the completion of the survey, we offered participants an information sheet explaining our project, providing specific information from the VDH website about arsenic as a naturally occurring contaminant, and providing contact information for our team and the VDH (Appendix B.2, page 71).

Results:

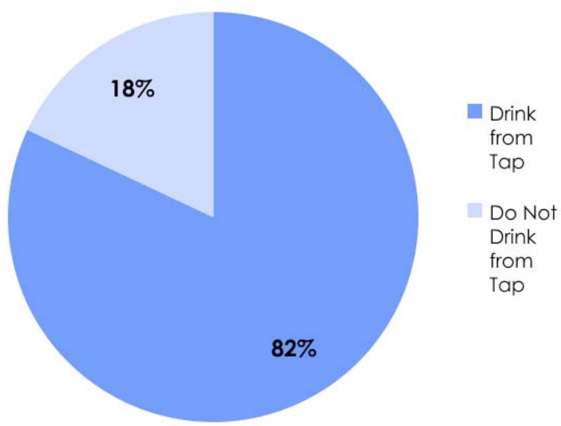


Figure 2-2a. Private well owners who drink tap water vs. those who do not. (n=124)

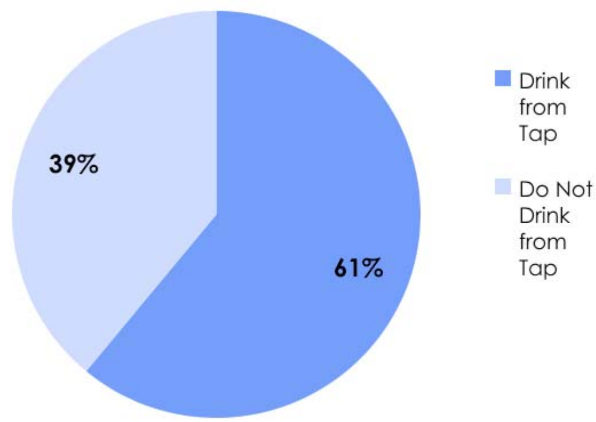


Figure 2-2b. Families with children under 12 years of age who drink tap water vs. those who do not. (n=23)

- The majority of surveyed well owners drink from their tap though families with children under 12 years of age were less likely to drink from their taps.
- The discrepancy indicates that families with children are more dubious regarding their tap water and while no data suggest families test more often, families with children appear to be more conscious about the possibility of contamination. This may suggest a higher degree of receptiveness to testing recommendations amongst families with children.

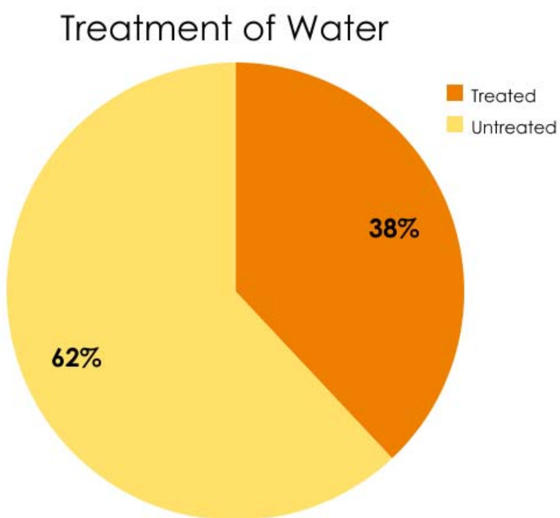


Figure 2-3a. Private well owners who treat their tap water vs. those who do not. (n = 124)

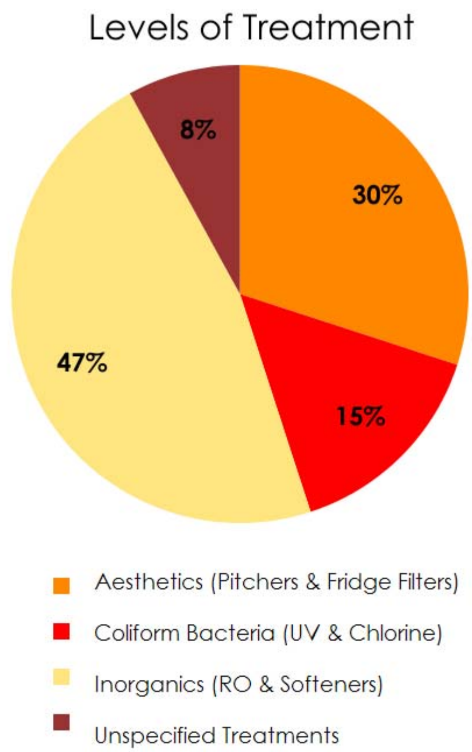


Figure 2-3b. Reported types of treatment, within those surveyed who *do* treat their water. (n = 47)

- While a sizeable portion of the surveyed well-owners treated their water, about a third were addressing purely aesthetic concerns and less than half were treating their water for inorganic contaminants. Many are under the impression that Brita© filters made tap water safer or "cleaner".

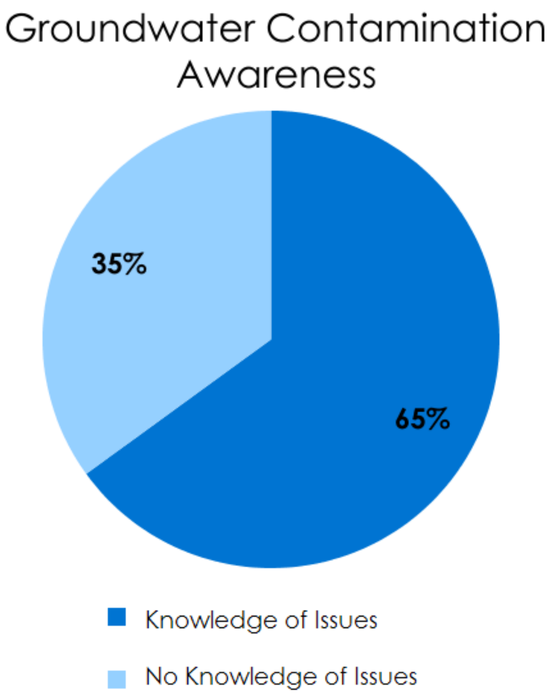


Figure 2-4a. Private well owners who claimed awareness of any water contamination issues. (n=124)

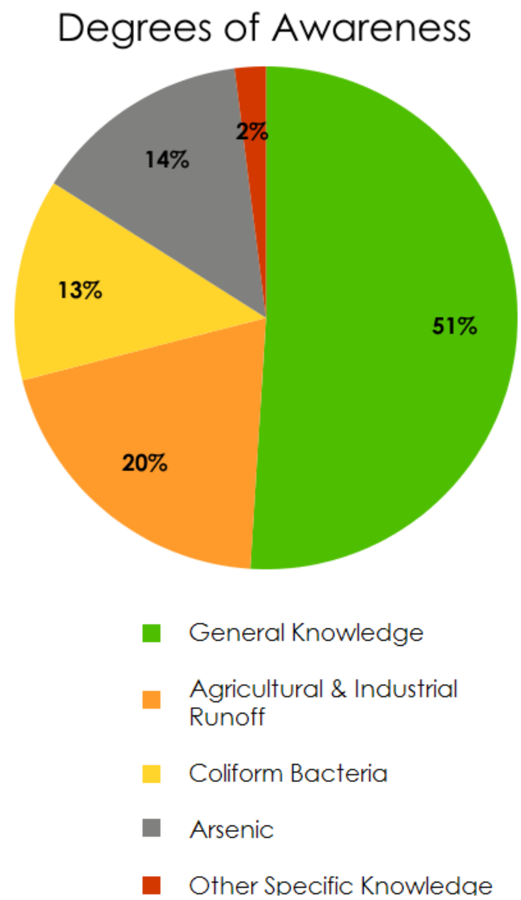


Figure 2-4b. Degrees of knowledge regarding water quality issues, within those who claimed any knowledge. (n = 80)

- Many respondents claimed to have general knowledge, but informed knowledge of contamination issues is scarce and knowledge of arsenic contamination specifically is marginal.

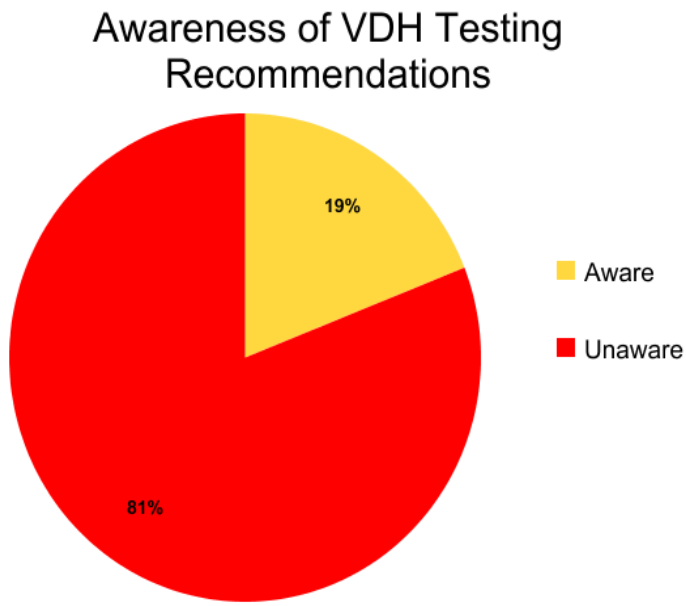
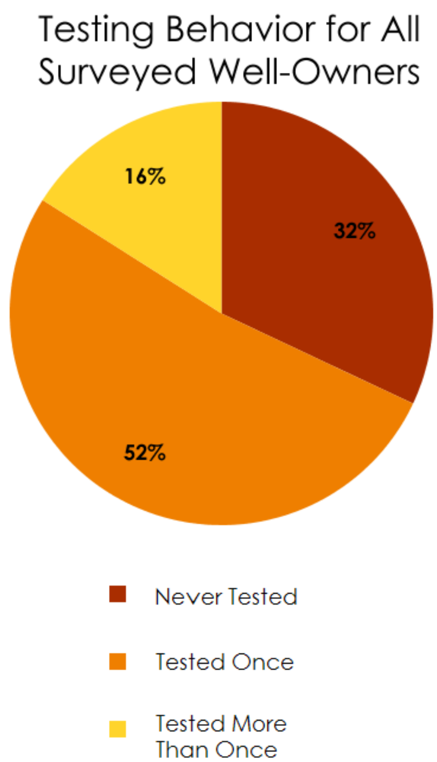


Figure 2-5. Surveyed private well owners who were aware of the VDH testing recommendations vs. those who were not. (n=124)

- The overwhelming majority of surveyed well-owners had not heard of the recommendations. Along with the lack of informed knowledge regarding contamination, there arises a need for better outreach and dissemination of information.



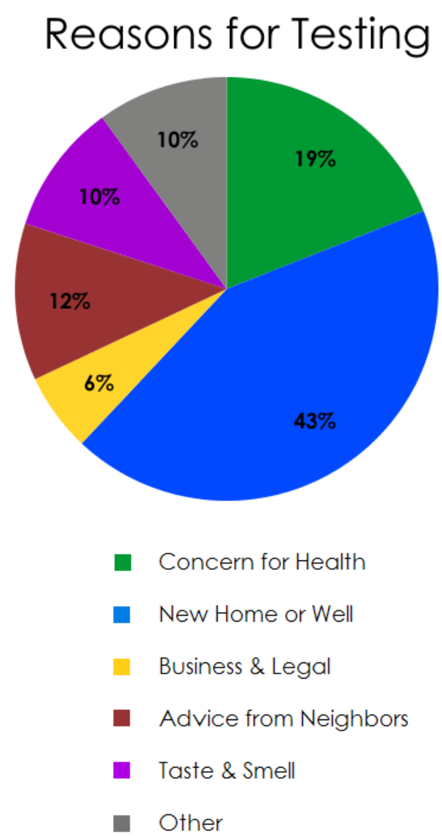


Figure 2-6a. Private well owners who claim to have tested vs. those who have not. (n=124)

Figure 2-6b. Given reasons that well owners tested their water. (n = 84)

- Despite a seemingly favorable percentage of private well owners who have tested, the lack of testing frequency and knowledge of test results suggests that most are testing in a cursory manner without paying close attention to what and why they test. Informed well testing is very limited and an effort should be made to educate well owners on why testing is important to health and how to interpret the results.

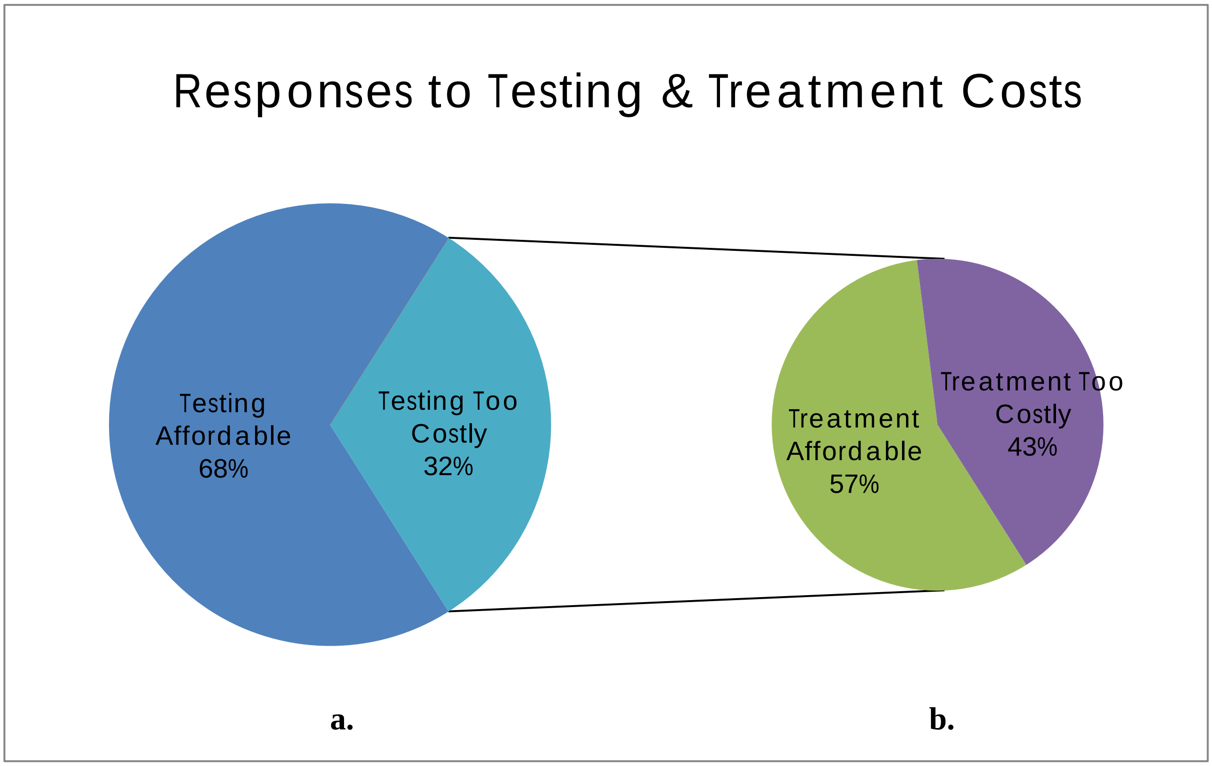


Figure 2-7a. Private well owners who perceived testing to be affordable vs. those who perceived it as too costly. (n=124)
Figure 2-7b. Private well owners who were willing to pay up to $500 for treatment *and* perceived testing as too costly vs. those who were not willing to pay up to $500 for treatment *and* perceived testing as too costly. (n=74)

- Most respondents are willing to pay for treatment if the need is present, but apparently many are unwilling to spend the time and money to evaluate the safety of their well water. Inconvenience and cost are clear barriers to testing, though treatment seems like it would naturally follow once a problem has been identified.
- Initial testing is a major obstacle in the treatment of private wells as most of our respondents view health as a priority, yet were unwilling to test due to a perceived lack of time and money.

Responses to Potential Barriers to Testing	
Percentage of Vermonters Surveyed	**Barriers to Testing**
40%	It never occurred to them to test
35%	Felt that testing was too inconvenient
35%	Unconcerned about the health risks
32%	Thought it would lower their property value
19%	Could not find information on how to test
16%	Thought treatment would be too costly

Table 2-3. Barriers to testing as perceived by private well owners.

Discussion:

Vermont Families Care About Water Quality

The majority of private well owners surveyed drink the water from their tap on a regular basis, suggesting a general confidence in Vermont's groundwater quality (Figure 2-2a). Among Vermonters with young children at home, the proportion of households who drink regularly from the tap dropped considerably (Figure 2-2b). This finding supports the general observation of our survey team that survey participants with children at home appeared generally more concerned about water quality, and were specifically concerned with their children drinking from the tap. However, we also found that only 52% of families surveyed have tested their water source, compared to 72% of well owners without children (n=23 and n=101, respectively). While our results suggest that Vermont families are particularly concerned with the quality of water consumed by their children, they do not appear to value water testing as a way to protect their children's health. There is clearly a need for increased education and facilitation of water testing among Vermont families. Fortunately, because our results show that Vermont families are particularly interested in drinking water quality issues, they are likely to be receptive to information about naturally occurring contaminants and the need for regular water testing. The VDH should consider specifically targeting families as part of any water quality education campaign.

Vermonters Don't Know Enough About Naturally Occurring Water Contaminants

Our results show that the majority of Vermonters surveyed have tested their private well water (Figure 2-6a). However, very few participants knew specifically which tests had been performed, and only 24% went on to test their water again. As we have seen in the previous chapter, since 2004, only about 300 Kit C tests have been performed in Rutland and Bennington counties combined. If the majority of Vermonters were testing their water for inorganic compounds, there would be substantially more Kit C records. It is likely, therefore, that of the Vermonters surveyed who claimed to have tested their water, the majority probably tested solely for coliform bacteria.

Our results show that there is limited specific knowledge of local water contaminants, and their associated health risks (Figure 2-4b). The majority of this knowledge was further limited to surface water issues, rather than naturally occurring groundwater issues. Participants mentioned run-off from agriculture and industry seeping into the groundwater, and were also aware of bacteria contamination issues, especially E. coli. Many participants assumed there was no need to be concerned about the quality of their water because there were no obvious sources of surface or anthropogenic contamination. One Castleton resident mentioned that he was not worried as their well was located was safely away from farms and golf courses. Another from the town of Wells believed that his water was safe because he lived on a mountain.

Two naturally occurring water quality issues did arise in the interviews with some frequency: the hardness of water and the presence of sulfur. These issues are, however, associated with obvious physical characteristics, such as lime build-up and odor, so they can be easily identified without a water test. Those who had not tested perceived no physical problem with their water and generally adopted the attitude of, "If it ain't broke, don't fix it." One women said she did not test because her water is "clear, tastes good, and has no smell." There was very little understanding of odorless and tasteless water contaminants, such as arsenic. There was also a general assumption that in the absence of immediate and obvious water related health issues, there was probably no reason to suspect poor water quality. Many older well owners cited their good health despite persistent water consumption as proof of the quality of their water.

Vermonters' Knowledge of the VDH's Testing Recommendations Is Inconsistent

The people who were aware of VDH recommendations for water testing had heard of these recommendations in a variety of ways. Several people heard about the recommendations for testing from a relative, neighbor or co-worker. A few respondents indicated that water-related professionals, including well drillers and plumbers, had informed them of the recommendations. Only two of our respondents had been advised to test by physicians. Both incidents were prompted by concern for children, and only focused on one possible contaminant. While one physician was examining a sick patient, the daughter of a respondent, he suggested testing for pesticides. In the second case, another physician was concerned that the children of the household were consuming too much fluoride since they were taking supplements, and suggested testing the well water for fluoride. The VDH needs to more purposefully engage with communities and relevant professionals to spread the word about water testing recommendations in Vermont.

Vermont Well-Owners Need to Understand the Importance of Repeated Testing

The VDH recommends regularly testing because groundwater quality is not static. In addition to anthropogenic activity, geochemical reactions affect the composition of the water. Most people seem to have a better awareness of anthropogenic affects on their well—for example, if your neighbor drills a new well, the flow from your well may be affected. However, few people realize the dynamic nature of groundwater and that the weathering of the bedrock, and subsequent chemical reactions, may lead to the release of certain harmful substances. In the case of Bjorn's family, the concentration of arsenic increased within just two months. Changes in arsenic concentration levels are difficult to predict. Generally, high pH (greater than 8.5), strongly reducing conditions, and the presence of anions like bicarbonate and phosphate are primarily responsible for arsenic mobilization and contamination (Smedley and Kinniburgh, 2002). Yet, aquifer material with elevated arsenic concentrations can produce uncontaminated groundwater if conditions do not foster arsenic mobilization. The VDH recommends testing every 5 years for inorganic chemicals. However, particularly concerned well-owners may consider testing more often.

Money Is Not An Issue When Health Is On The Line

The majority of Vermonters surveyed were unconcerned with the cost of water testing (Figure 2-7). However, of the participants who were concerned with the cost of testing, only 43% were also concerned with the potential cost of treatment. Moreover, of the 74 participants asked, 81% indicated that they would be willing to pay $500 to treat their water if a contamination problem was found. The cost of testing is only $100, even though Vermonters surveyed seemed more opposed to this cost than to the higher cost of treatment. This discrepancy clearly indicates that Vermonters take the health implications of water quality seriously. Any hesitance towards testing, financial or otherwise, is likely due to a general lack of education about the ease and importance of private water testing in protecting personal health.

Vermonters Need to Know More About Water Treatment Options

Many survey-respondents were confident in the adequacy of their annual chlorine shots, either because they were unaware of issues beyond bacteria or because they were unaware that chlorine only addresses bacteria contamination. Furthermore, there is an extensive use of filters, such as Brita © filters or filters built into refrigerators. This may lead to a false sense of security as these types of filters only improve the aesthetic qualities of the tap water while ignoring more serious issues. Fortunately, there exists a readily available technology that removes arsenic as well as other contaminants called a reverse-osmosis system. While Bjorn's grandfather had to spend 40 hours researching for this affordable solution, if this information were more accessible to all well-owners, the issue of elevated arsenic in groundwater would be easily treatable.

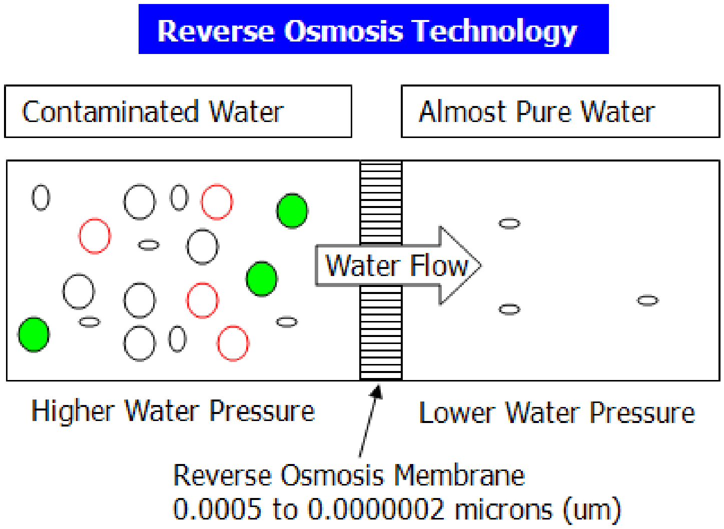


Figure 2-8. A reverse-osmosis filter installed under a kitchen sink removes many harmful inorganic chemicals.

Conclusion:

Private well owners surveyed in this study are confident in the quality of their groundwater source, and unconcerned with the necessity for repeated testing. This problem likely stems from the fact that Vermonters' knowledge of water contamination is mainly limited to issues of surface water pollution and bacteria. Private well owners are simply not aware that naturally occurring contaminants, such as arsenic, may be present in their drinking water, and that the only way to know for sure is by conducting regular water tests. Our results suggest that if Vermonters are given adequate cause to be concerned about the quality of their water, they will act accordingly to address the situation, even to the point of paying for treatment. The VDH needs to provide Vermonters with good, local information about water contaminants, and their associated health risks, so that Vermonters can take responsibility for the quality of their private water.

We think an effective education campaign that would address the needs highlighted in our results section would achieve the following:

- Increase public awareness of specific local groundwater contaminants and their associated health risks.

- Emphasize the importance of regular water testing as it relates to general health, safety, and well-being.
- Provide information about how to test and the ease with which testing can be done.
- Provide support for interpreting test results and assessing various treatment options.
- Target families with children specifically, as they appear to be particularly receptive.
- Emphasize the question of, "Why Not?" Water testing is an easy and important way to protect your family's health.

It is our hope that through education, private well owners will recognize the value of well testing and the associated risks of not testing. For more information on education campaigns, see Recommendations for Improved Education and Outreach (page 44 and Appendix B.6).

Limitations:

While we exceeded the VDH request of 100 surveys, it is difficult to make generalizations about Vermonters based on 124 surveys of well owners from a very specific geographic region. Moreover, the selection of survey sites where interviews were conducted may have biased our survey sample and excluded certain members of the well owner population.

The inexperience of our Survey Team in conducting survey interviews was perhaps the largest complication in our study. Although we consulted with Professor Michelle McCauley of the Middlebury College Psychology Department and Joanne Calvi of the VDH, we were not particularly trained to conduct public surveys. The interviews were scripted, but the tone, mannerisms and comfort level of each interviewer varied greatly, and many of the surveys were incomplete due to accidental omissions or miscommunication on the part of the interviewers.

A related complication was the effect that the presence of an interviewer had on the ability of participants to provide thorough, honest answers. The wording of questions, the tone of the interviewer's voice, subtle mannerisms, and the general ease of the participant may have contributed to an atmosphere of expectation, influencing the participants' responses. Within the framework of our survey, there was likely a perceived expectation that people were supposed to care about their health, and that people were supposed to know about water issues. Our results showed that the majority of surveyed Vermonters who claimed to know about water contaminant issues did not, in fact, know about any particular contaminants or concerns. This may be an indication that many of our participants were responding in part to expectations inherent in our questions, rather than responding honestly to the questions themselves. It would be impossible to assess the full impact of this trend, but it is important to recognize its prevalence in clouding the answers of our participants.

Although our survey was designed to provide flexibility for participants to share with us their knowledge of water quality issues, whatever that knowledge might be, there was no clear means of expressing a response of apathy. As a result, participants who were genuinely unconcerned tended to default to negative answers that may not fully or accurately express their beliefs or behaviors. For example, we observed that apathetic participants generally tended to answer "False" to the statement, "I am concerned that testing might be too expensive." This response likely had very little to do with testing or money, but more to do with the fact that the participant didn't value testing in the first place. Depending on the number of responses that were more apathetic than truthful to this question, the proportion of surveyed Vermonters who are concerned about the cost of testing may appear unrepresentatively low. In fact, "False" was the default response for all of the true/false "Barriers to Testing" statements, and so all of our percentages in the "Barriers to Testing" may suffer similar biases.

In the case of open-ended questions about pre-existing knowledge and habits, in which the obvious expected response was unclear, there tended to be a default towards non-committal responses. Many participants answered "Not Sure" or "Don't Remember" when asked about past well testing, treatment, and knowledge of water contaminant issues. Some of these respondents may have been genuinely unaware. It is likely, however, that many were simply unsure of the expected response and unconfident in their own knowledge. These participants may have chosen to withhold information and feign ignorance rather than risk embarrassment. The extent of this trend in our surveys, and its impact on our dataset, is unclear.

Physicians

Goal:

The results of our principle survey indicated that physicians in the Taconics region generally do not mention groundwater quality or testing to their patients. We thought it would be useful to better understand the physicians' perspective. To contact physicians we acquired a database from the VDH and, combined with information found in the Yellow Pages (http://www.yellowpages.com), we compiled a list of the physicians that served residents of our study area. Because many residents of our focus area travel into Rutland City for medical care, we included primary care physicians from the whole county. We attempted to contact 26 physicians, and ultimately spoke with six from the region: one in Poultney, one in Castleton, three in Rutland, and one in West Pawlet.

Methods:

Initially we designed a short questionnaire and tried to contact physicians for phone interviews (See Appendix B.3). Unfortunately, only one out of 26 physicians could speak with us. We did not expect it to be so difficult to contact physicians via telephone. We instead drove to physicians' offices to try to speak with them in person. This proved to be much more effective, and we spoke to five more physicians.

Results:

- 1/6 recommend well testing, but only to families of young children.
- 5/6 never mention testing to their patients.

  Of those who do not mention testing:

  - 1/5 are willing to mention private well contamination issues to patients that live outside the public water supply.
  - 4/5 are not willing to mention private well contamination issues to patients.

- 4/6 would be willing to have a pamphlet about arsenic in the waiting room
- 0/6 physicians ask patients on private water whether or not they test their wells.

The one physician we reached by phone was excited to speak to us; he told us that he is a major advocate of testing private wells. "I know where my patients live, and I know the boundaries of the public water supply," he told us. "During pediatric check-ups, when I know the family lives outside of the public water supply, I always strongly encourage testing." For contrast, one physician said that he did not know anything about arsenic, and suggested that we talk to the VDH. Several physicians resisted the idea of mentioning private well water testing and contamination during check-ups, indicating that it would scare patients. Physicians with offices in Rutland seemed to assume that the majority of their patients use the Rutland City public water supply.

Discussion and Limitations:

Because the first interview went so positively, we were under the impression that perhaps many physicians do recommend testing. Considering that only two of the 124 private well owners surveyed reported that their physician had ever mentioned testing, this surprised us. However, this physician's responses are not representative of physicians in the area. The five additional physicians revealed a more typical medical attitude toward private well contamination: they have low knowledge of private well contamination, and are reluctant to bring up the subject during check-ups. This reluctance may stem directly from physicians' lack of knowledge regarding this issue.

The possibility that physicians assume their patients drink from public water supplies is problematic. Small Vermont towns usually don't have primary physicians in their immediate area, and thus go into the more populated community to seek care. In more populated areas, these more rural "outsiders" make up the minority. It is possible that physicians do not spend much time considering rural issues like private well contamination.

Improved information flow between the VDH and primary care-givers in Rutland County could dramatically enhance the dissemination of information to patients. Physicians who are both educated about private well water issues and aware of their rural patients are more likely to regard water quality issues as relevant information to share with patients. The medical opinion of the physician is a valuable and trusted source of information to patients. This relationship is distinct from the VDH's relationship with the "public," and puts physicians in a unique position to improve awareness and testing patterns. At the very least, providing an informational pamphlet about private water testing in medical waiting rooms could help make this information more available to the public.

The largest limitation of this survey process is that we were only able to speak with six of the 26 physician in the area. Fortunately, three of the six are the only physicians in their rural town. In this regard, the survey was more comprehensive. Nonetheless, it would have been informative to have spoken with more physicians in Rutland County. Additionally, our survey participants were self-selecting.

Well Drillers

Goal:

Well drillers play an integral role in the private drinking water industry, not only in the drilling of new wells, but also through routine well maintenance and service calls. Well drillers serve a large population, so partnering with a relatively small number of well drillers could reach a many residents. Their local expertise and respected status among their clients presents an opportunity for collaboration with the VDH to disseminate information about private water testing.

To contact well drillers, we downloaded a spreadsheet of all drillers certified in the state of Vermont from the VDH website (http://www.vermontdrinkingwater.org/wells.htm; Appendix B.4). Within the spreadsheet we organized drillers by company. We then called the main office of 16 companies throughout the state of Vermont and asked to speak to an available well driller. In total, we spoke with five well drillers from five different companies.

Methods:

With the help of Peter Ryan, Diane Munroe, and the ENVS 401 Policy Group (Ashley Cheung, James Hexter, Mark Kostrubiak, Pier Lafarge and Nicole Vaughan) we compiled a list of questions for brief phone interviews (See Appendix B.5).

Results:

- 4/5 well drillers initiate conversations about groundwater quality with their clients.
- 4/5 are aware of VDH testing recommendations and share them with clients.
- 4/5 said that their clients don't consistently voice concerns about specific water quality issues.
- 1/5 said their clients are typically worried about E. coli and coliform bacteria.
- Contaminants that more that one well driller was worried about: E. coli, coliform, iron.
- Contaminants mentioned once: sulfur, radionuclides, manganese.
- 3/5 well drillers are aware of arsenic as an issue in certain locations.
- 4/5 well drillers think it's a good idea for all well drillers to share information about groundwater contaminants and testing.

Discussion and Limitations:

The limited sample size of this survey severely limits its weight in representing the Vermont well driller population, and because we called main offices and asked to speak to any available well driller, our survey population was self-selecting.

Nonetheless, three factors from this survey indicate that it would be worthwhile for the VDH to reach out to the well drilling community to aid in information distribution. Firstly, well drillers are generally well-informed about water quality, and groundwater contamination issues more specifically. Secondly, well drillers are aware of the VDH private well testing recommendations. Finally, well drillers are open to sharing information. This is evidenced by the fact that they already do so.

We must also recognize that the nature of the information that well drillers currently share is uneven and often location-specific. However, coordination within the community and cooperation with VDH could easily turn well-drillers into an adjunct educational group.

Recommendations for Improved Education and Outreach

1) Improve the VDH Website (Appendix B.6, Section 1)

The VDH's "Safe Water Resource Guide" and "Testing Your Water Supply" web-pages are good, user-friendly, and informative resources. However, the "Arsenic in Drinking Water" page needs to be updated and expanded. We have provided the framework for a few simple changes that will vastly improve the usefulness of the page for Vermont's private well owners.

2) Create an Informational Arsenic Pamphlet for Vermont (Appendix B.6, Section 2)

Our research has identified the potential for dissemination of information through collaboration with well-drillers and physicians. But Vermont does not yet have any printable education materials containing relevant information about naturally occurring arsenic in private well water. An informational pamphlet about arsenic is a necessary component of any arsenic education campaign.

3) Implement a Strategic Plan for Media Outreach (Appendix B.6, Section 3)

Surveyed Vermonters overwhelmingly recommended that VDH use the media as a means to educate the public about water contamination and testing issues. We have developed a strategic media outreach plan that identifies the most effective means of media communication, and the most advantageous occasions to make a public statement.

4) Educate the Public by Educating Our Children (Appendix B.6, Section 4)

a) Engaging Youth to Spread Awareness about Contamination Issues

b) Private Groundwater Week: A Feasible First Step

Our study determined that families with children are likely to be particularly receptive to information about private well water contaminants and testing. The VDH should target these families by working with public schools and community organizations to educate children about the issue of private well testing.

Chapter 3: Policy Group

Introduction

The state of Vermont currently has no requirements for the testing of private wells despite the fact that an estimated 40% of Vermonters use private water systems for their drinking water. During the 2003-2004 legislative session, a bill was introduced calling for more stringent testing requirements for private residential wells in Vermont; currently, Vermont only has testing recommendations which are non-enforceable and often ignored. Bill S.110, introduced by Senator Lyons of Chittenden County, Senator MacDonald of Orange County, and Senator Munt of Chittenden County, aimed to adopt testing requirements for the health benefits of those who consume water from a private drinking water supply. The required testing parameters as noted in the bill included total coliform bacteria, lead, arsenic, nitrate, and gross alpha radiation. S.110 would have required that this test take place at the time of real estate transactions, requiring sellers of property to test the water supply and provide the results to the buyer. S.110 was not enacted into law due to concerns around cost, information disclosure, barriers to property transfers, and burden of responsibility ("Private Water Supply Testing," Vermont Legislative Bill Tracking System).

Goals and Methods

The goal of our policy group was to provide our community partner, Senator Virginia Lyons, one of the original sponsors of S.110, with information pertinent to advancing this policy discussion in Vermont through extensive research of the policy initiatives of other states. Along with our state research, we also performed a cost analysis in terms of testing and remediation costs, and researched parallels that can be seen in legislation concerning radon and lead. We spoke to the family of Bjorn, a five-year-old boy who suffered from arsenic poisoning in Whiting, Vermont, and they assisted our project by compiling a personal narrative that would help portray the humanistic side of this public health issue (Appendix C.1). They also provided us with a detailed breakdown of their remediation costs, which were much lower than the amount they spent on health care when attempting to diagnose Bjorn's illness (Appendices C.2, C.3). We also worked with the survey group to come up with willingness to pay data and information from well drillers that could be useful in passing legislation. Finally, we used our extensive research to create policy proposals that the legislature can work off of in the 2010-2011 legislative season.

Policy Proposals

Scaled Approach – from most stringent to least stringent

1. Mandatory Testing of Private Wells Upon Drilling and at Point of Sale

I. All newly drilled wells shall be tested for all the contaminants listed in this bill.

II. Require testing of private wells during property transfer.

1. It is the responsibility of the seller to arrange for testing.
    a. To ensure that the sample is from the well in question a witness is required to be present when the sample is taken. The realtor shall ensure that a witness is present and shall obtain a witness signature.
        i). The Vermont Department of Health (VDH) and Department of Environmental Conservation (DEC) shall cooperatively create rules to regulate the witness component of the sampling requirements.
2. Buyer and seller can negotiate terms of payment for testing and (optional) remediation.
    a. Positive test results or failure to agree upon terms of remediation grant the buyer the right to terminate the contract.
3. The DEC and VDH will work collaboratively with the Vermont Realtors Association on how best to provide disclosure information between the buyer and the seller if test results are found to be above acceptable levels.
4. The results of the well testing shall be added to the Vermont Residential Real Estate Sales Disclosure Statement.

    5. Failure to comply with testing requirements will not invalidate certificate of transfer.

III. Property owners are required to test new wells upon construction of a new well.

IV. The Department of Environmental Conservation and the Health Department shall create a new testing kit, Kit W to test for all substances specified in this bill.

    1. Kit W shall test for the following naturally occurring contaminants: arsenic, lead, uranium, gross alpha radiation, and coliform bacteria.
    2. No party will be held liable for these contaminants and their effects since, except for bacteria, they are primarily naturally occurring and not anthropogenic.

V. The legislature authorizes the Vermont Geological Survey (VGS) to create a groundwater map of Vermont showing potential areas of contamination risk.

    1. The locations of contaminated wells shall be used by the DEC, VDH, and VGS to create maps of contaminants and their correlation with bedrock, or other natural phenomena.

VI. If test results are found to exceed EPA MCLs for contaminants tested in Kit W, the Vermont Department of Health shall send notifications to all neighboring well owners indicating the presence of a high level of contaminants in a nearby well.

    1. Neighboring well owners shall be defined as those within 500 yards of the contaminated well or those within a correlated bedrock region as determined by the VGS, VDH and DEC.
    2. The property address and names of contaminated well owners shall not be included in this mailing.

VII. The Vermont Department of Health and DEC shall develop and implement a public education campaign designed to raise awareness of non-anthropogenic groundwater contaminants in Vermont.

    1. Materials should focus both on potential health effects and remediation options and costs.
    2. The legislature directs the Vermont Department of Health to work with private physicians to encourage the inclusion of questions concerning groundwater contamination in annual health checkups.

3. The VDH will make the above materials available to private physicians, dentists and clinics for distribution to patients.
4. The VDH shall also make the above-stated materials available to all realtors.
5. Well-drillers are required to provide the above VDH materials to their clients.
6. Materials developed by the VDH and VGS are to be distributed to town offices, state health clinics, public libraries and schools.

2. Private Well Testing Refund Program

I. Provide a direct refund for homeowners who can demonstrate that they have tested their private well drinking water with Kit W and have an appropriate level of financial need (to be determined by the VDH).
   1. Note: Eligible private wells are defined as those used as a source of drinking water.

II. A dedicated fund shall be established within the Vermont Department of Health to dispense refunds to cover the cost of testing for the contaminants mandated by state law (Kit W).

III. Funding shall begin in 2012 (or two years after passage of requiring legislation) and end in 2022 (or ten years after passage).

IV. The Vermont Department of Health is directed by the Legislature to develop a new testing kit, Kit W, that will test for arsenic, lead, gross alpha radiation, uranium and total coliform bacteria.

V. Refund shall not exceed the cost of testing plus administration costs ($120 for Kit W through the VDH).

VI. Testing analysis shall be carried out only at a designated DEC laboratory.

VII. Homeowners would apply directly to the refund program through an online application administered by the Vermont Department of Health. Qualifying applicants would be able to demonstrate a certain appropriate level of financial need to be determined by the VDH.

VIII. Potential Funding Sources:

1. Total testing cost for Kit W would be approximately $108, leaving a $12 administration charge that could be used to slowly fill the refund program account over the first two or three program years.
2. Transfer of bottle recycling rebate monies to be used as seed funding for well testing refund program within the VDH.
3. Permit monies from the Water as a Public Trust legislation (S.304).
4. Federal Water District funds could be used to cover initial testing costs for applicants to the refund program.
5. EPA private well water grant program (would need to be created in collaboration with the Vermont Congressional delegation).

3. Education, Notification and Mapping

I. If test results are found to exceed EPA MCLs for contaminants tested in Kit W, the Vermont Department of Health shall send notifications to neighboring well owners indicating the neighborhood of the contaminated well but not the property address or names of homeowners.
   1. Notification extent should be determined by the VDH and DEC, in consultation with the VGS.
   2. Where possible, bedrock analysis should inform extent of notification area in a given instance.
   3. Where correlation with contaminant-bearing bedrock is not possible, all residents within a 500 yard radius of the positive test result shall be notified.

II. The Vermont Department of Health shall develop and implement a public education campaign designed to raise awareness of non-anthropogenic groundwater contaminants in Vermont.
   1. Materials should focus both on potential health effects and remediation options and costs.
   2. The legislature authorizes the Vermont Geological Survey to create a groundwater map of Vermont showing potential areas of contamination risk.

3. Materials developed by the VDH and VGS are to be distributed to town offices, state health clinics, public libraries, elementary schools and through direct mailing of materials with annual property tax assessment.
4. The legislature directs the Vermont Department of Health to work with private physicians to encourage the inclusion of questions concerning groundwater contamination in annual health checkups.
5. The VDH will make the above materials available to private physicians and clinics for distribution to patients.
6. Well-drillers are required to provide the above VDH materials to their clients.

<u>Other Possible Variations of Policy</u>

1. Separate regulations for families with children: Research has shown that children are more susceptible to low levels of arsenic in drinking water than adults (Rogan and Brady 2009). The case of Bjorn is a prime example of this. While it may not be feasible at this time to pass policy with specific regulations for families with young children, this may be something that should be considered in the future as public awareness and support for private well testing increases. Additionally, there is existing precedent for regulations that aim to protect children. For example, lead (Pb) policies exist for children under the age of six (see section on "Radon and Lead Parallels" for more detail), and car seat laws exist for young children as well. Policy protecting children from contaminants in drinking water can prevent unnecessary health risks, developmental risks, and health care cost burdens for families.

2. Variation in regulations on a county to county (or town to town) basis: Research has shown that the probability of elevated levels of arsenic or other contaminants in groundwater is correlated to the bedrock geology of the area. Tailoring regulations by these probabilities and by bedrock mapping can help cut costs by limiting the amount of unnecessary testing. However, the limitations of these probabilities and the uncertainties of the current breadth of scientific research gives reason to have state-wide regulations for the time being. Additionally, it may be simpler and more accepted to start with statewide regulations as legislation is first being passed and then introduce regulations tailored by region later on.[1]

Limitations of Proposals

1. Sources of funding are scarce. We have researched and brainstormed possible sources of funding to assist with the costs of testing and remediation (see section on "Creative Sources of Funding"), but the funds that can feasibly be raised are limited.

2. Enforcement is difficult. There are still those on private wells who will continue to drink untested water despite proposed legislation. Our research has shown that other states have weak enforcement policies as well, as it is difficult to regulate such a personal matter without creating extensive management costs. Failure to comply with testing regulations or remediation does not prohibit the property sale from being completed in other states (see section on "State Research" for more details), so laws concerning private well testing mainly ensure that all parties in a real estate transfer know the facts about the well water so that they can make well-informed decisions.

Cost Analysis

Creative Sources of Funding

1. Redirecting taxes collected from water bottlers to fund testing.

2. Removing bottle rebates to consumers and redirecting bottle deposits to private well water testing.

a. Rather than allowing consumers to redeem bottles for rebates, use the money gained from bottle deposits to establish a fund that would provide financial aid for the testing of wells for a given period of time. Some time will be required to allow for funds to accumulate before distribution.

[1] The exact regions that are more affected by arsenic can be found in the Spatial Analysis chapter of this report.

b. Another option is to retain bottle rebates to consumers and direct only unclaimed deposits to the well water testing fund.

3. Initial overcharge on testing kits for first two years or so of required testing. Revenue generated from overcharge fees could then be used to start a fund that can be used as financial assistance for testing in future years.

4. The Vermont Association of Conservation Districts, which currently provides free well water testing for farms (VACD.org).

6. Possible federal or EPA funding.

Testing Cost Predictions

Breakdown of Kit W Cost

Bacteria - $14

Lead - $12

Arsenic - $12

Gross Alpha - $45

Uranium - $25

Extra costs of managing program - $12

Total = $120

Reasoning for choosing these contaminants:

This is a list of commonly occurring groundwater contaminants in Vermont.

Estimated Costs of Testing in Vermont– Demographic Calculations

Vermont Population = 621,760

VDH estimates 40% of population uses private bedrock wells for drinking water

40% x 621,760 = 248,704

Average household size in Vermont = 2.44

Approximately 101,928 households in Vermont on private bedrock wells

Cost of Kit W Test = $120

Total Cost of Testing = $12,231,360

(per year: $60,000 [assuming 500 kits/year])

Rural Household Poverty Data from Spatial Group:

10,000-16,000 Vermont households are in rural areas and under the poverty line.

Calculations:

The Spatial Group used the following data and methodology to estimate the rural household poverty rate:

1. Total population per county from Census data “2006-2008 American Community Survey 3-Year Estimates”.
2. Average household size (HH) from Census data 2000.
3. Calculate estimated HH number by dividing rural population by HH size to get number of rural HH in each county.
4. Got rural population poverty rate per county from USDA.
5. Multiply (total population per county) by (rural population poverty rate) to find population in poverty.
6. Divide (population in poverty) by (average household size) to find estimated number of households in poverty.
7. Divide (households in poverty) by (number of rural households) to find a percentage of rural households in poverty.

<u>Remediation Cost Research</u>

Reverse osmosis (RO) systems can effectively and easily be used to remove all of the contaminants in Kit W. RO systems can be installed at the point of use (i.e. under a sink or other). These systems can be purchased for as little as $115, with multiple options under $200. The other option is to install an RO system that treats all the water going from the well to the dwelling. These are in many cases overkill as the contaminants in Kit W are of concern when ingested as opposed to being used for other uses such as watering plants and bathing. Whole house systems are significantly more expensive and can be purchased for $515 and upwards; there are many options under $700. (“Reverse Osmosis System,” Google Shopping)

In situations with hard water, RO systems require the use of a water softener. Water softeners are already present in most homes in which this issue would arise. In the case that a water softener is needed and not yet installed, they can be purchased at $300, and many options are under $500. (“Water Softener,” Google Shopping)

The overall costs of both a water softener and an RO system can be as little as $415 plus installation costs and fees (which can cost several hundred dollars).

State Research

Chosen States

States were chosen based upon four factors. The first group of states were those in the region that are expected to have similar bedrock to that found in Vermont and are therefore likely to have similar amounts of arsenic present in their groundwater. These states include those located in the northeast; New Hampshire, Maine, Massachusetts, Connecticut, Rhode Island, New York and New Jersey. The second set of states are those located in the southwest and the Rocky Mountain range, these areas have been found to have high levels of arsenic in their groundwater. These include, Arizona, Colorado, Montana, Nevada, New Mexico, Utah, Wyoming, and Idaho. California was included as an example of a state with a similar political atmosphere to that found in Vermont. The final state Wisconsin was chosen as a representative of a state with industries similar to those found in Vermont (i.e. dairy farming). Table 3-1 shows a summary of our findings, for full details of our findings, see Appendix C.1.

Table 3-1. Summary of state research

State	Regulation	Funding	Variance by Locality?
Arizona	No	No	No
California	No	No	No
Colorado	No	No	No
Connecticut**	Yes	No	No
Idaho	No	No	No
Maine	No	No	No
Massachusetts	No	No	No
Montana**	No	Yes (Missoula County)	Yes
Nevada	No	No	No
New Hampshire	No	No	No
New Jersey**	Yes	Some	Yes
New Mexico	No	No	No
New York**	Yes*	No	Yes
Rhode Island	No	No	No
Utah**	No	No	No
Wisconsin	No	No	No
Wyoming	No	No	No

*No statewide requirements, however testing is required in certain counties.

**See "Details of State Research" (Appendix C.1) for more information

Radon and Lead Parallels

Radon

Radon testing is not required in Vermont. However, if a homeowner has done testing in the past, they must disclose that information to the buyer of the house should they decide to sell. Radon testing can be done on a short term or a long-term basis. The Vermont Department of Health provides free test kits to those who request them. If radon is found in a home, a radon reduction system can be purchased; cost ranges from $800-$2500. More information about radon contamination in homes in Vermont can be found through the Vermont Department of Health (“Radon,” Vermont Department of Health).

Lead

The Vermont Lead Law requires sellers of properties built before 1978 to disclose all the information they may know about the amount of lead-based paint that is likely to be present at the property—and the related potential hazards—to buyers, along with educational materials. This is done through a disclosure form about lead-based paint attached to the sales contract. Buyers have up to 10 days after the sale to investigate the condition of the property themselves for lead-related hazards.

If a qualified physician has diagnosed a child under the age of six with lead poisoning, the state commissioner of health must confirm the diagnosis and send an inspector or risk assessor to the property where the child lives, in addition to other places where the child is known to spend 10 or more hours per week. The commissioner then works with the involved parties, such as the child’s parents, the owner of the property, the child’s physician, and others, to develop a plan to minimize the child’s exposure to lead, usually through temporary or permanent relocation of the child. If this property is rented or leased, its owner is required to implement interim controls or an abatement strategy so that the hazard can be removed; if the owner does not adhere to a time frame agreed upon beforehand by the state, the state health commissioner will institute an action that will require remediation to take place regardless of the owner’s consent or involvement (“Lead Poisoning Prevention and Surveillance,” Vermont Department of Health).

Arsenic and Irrigation of Home Gardens

Arsenic can be taken up into plants since it is quite soluble and in an anionic form like many nutrients, but the degree to which this occurs is highly variable. Some plants can draw arsenic and other metals into their leaves and stems at doses that would easily kill other plants. These plants are known as hyper-accumulators and are actually used to remove As from As-contaminated soils. For example, rice is very good at drawing arsenic from the soil because it mistakes it for silicon, which has a similar shape and electrical charge, and is essential to the crop. Other plants are much less accumulating. Factors such as root structure, root/shoot ratio, and manure application have been found to play a role in As uptake for certain plants (Yao et al, 2009).

Most of the studies done on this subject have been about rice, since it is the staple grain in the parts of the world that are most chronically and tragically affected by geologic arsenic poisoning (Costanza-Robinson, 2010). The arsenic content in the groundwater of such parts of the world, such as Bangladesh, are substantially higher than the arsenic content in Vermont groundwater, so we do not foresee irrigation of home gardens being an issue here. However, our project is focused on drinking water and not on irrigation.

Willingness to Pay Data from Survey Group

Asking individuals about their willingness to pay for a certain amenity is a Stated Preference Technique often used to measure the benefits of an environmental good, such as clean drinking water (Goodstein, 2008). Since these questions are hypothetical and people are not actually making an expenditure, the realistic nature of their answers is uncertain. However, the survey data can still give us a general idea of whether or not individuals would be willing to pay for remediation given private well test results indicating contaminant levels above EPA MCL standards:

> When asked if they would be willing to pay around $500 USD for treatment (knowing that their wells were contaminated), only 16% of those surveyed said No. [N=74]

Well Driller Information from Survey Group

When asked if they think there is certain information that all well drillers should share with their clients, 4 out of 5 well drillers said that they think it is a good idea for all well drillers to share information about contaminants and testing.

Additional Comments From Surveyed Well Drillers:

-One well driller suggested regulating at property transfer. He also liked the idea of providing funding because people come to the company and want to know exactly what is in their water, but the costs of testing can be too expensive for some people.

-One well driller said that in Massachusetts, water testing is required in order to get a building permit, and the client has to sign a waiver saying that the well driller is not responsible for the water flow or quality.

-One well driller noted that new well testing varies by town, county, and state. He said it would be much easier if there were a statewide standard, so well drillers wouldn't have to figure it out on a town-by-town basis.

Conclusion: Next Steps

Clearly, arsenic, as well as other naturally occurring contaminants, is present in private groundwater wells in Vermont. We have found a simple and feasible way to test for these contaminants, and we have also outlined a simple economical method to remediate problems with these contaminants via reverse osmosis. To determine the viability of these proposals across the state, we have estimated the potential costs to the State of Vermont to pay for testing of all those in financial need. With this information as well as the background provided to us by S.110 and research from many other states, we have crafted our legislation proposals. Our proposals shall be presented to the legislature under the sponsorship of Senator Virginia Lyons. We hope that our research will provide ample evidence to the legislature to convince them that legislation is necessary to protect the health of Vermonters. Senator Lyons hopes to hold a press conference in the Spring of 2011 to increase awareness of this issue, and our class will assist with testimonies along with other stakeholders. Furthermore we hope that our presentation and report will be accepted by the legislature and that Senator Lyons' bill requiring groundwater testing will pass.

Conclusion

Our project began with a story of a child who suffered from health problems and developmental issues caused by elevated arsenic levels in his family's private groundwater well. This allowed us to put a face to the issue of arsenic contamination in Vermont and gave it a humanistic, relatable side. The experience of arsenic contamination put this family through considerable hardship and affected the development of a young child. However, there are other families who face similar, or even more serious, challenges and emotional trauma caused by the health issues of loved ones. Given the limited resources of the state and the Department of Health, one might question whether Vermont should focus on addressing naturally occurring arsenic in drinking water wells at the cost of diverting resources from other important public health issues.

In terms of improving public health, focusing resources on reducing arsenic exposure is necessary and efficient for several reasons. First, arsenic exposure leads to serious health effects including neurological complications and fatal illnesses. As with many health issues, the costs of taking preventative measures are much lower than treating the problem after the fact. Bjorn's family spent about ten times more on health care costs than on testing their water and installing the reverse-osmosis system. These costs, as well as emotional stress, could have been avoided by simply being aware of arsenic contamination and testing their drinking water. Second, there is an easy, affordable solution—the reverse-osmosis filtration system—that simultaneously filters out other drinking water contaminants. Because of this, protecting Vermonters from arsenic contamination is entirely feasible. In addition, arsenic can be used as a vehicle to address and increase awareness of other naturally occurring groundwater contaminants. Finally, in comparison to other harmful contaminants such as uranium, arsenic is a particularly prevalent concern in Vermont. In the past ten years, test results collected by the Vermont Geological Survey have shown that elevated arsenic has been the most prominent, harmful contaminant.

The three sub-projects of our class were designed to address the weakness of bill S.110 so that this important piece of policy could be more successful the second time around. More information was needed that addressed where the problem exists and its prevalence in different areas. In sorting and compiling all the available data, the spatial group has given policy-convincing evidence that this problem is widespread and needs to be addressed. Legislators also need to know the opinion of their constituents. Thanks to the survey group, information is now readily available about residents of Rutland County and nearby towns in terms of their awareness and concern about drinking water contamination and their willingness to pay for treatment of their water in order to protect their health. Finally, the policy group has filled in key information gaps in finding examples of similar policies in other states and precedents in Vermont, calculating credible cost estimates for implementing the policy, and suggesting incentive mechanisms. Although these three groups had separate foci throughout the semester, all three projects were fundamentally interrelated and supported one another in reaching the common goal of addressing the issue of arsenic contamination in private drinking water wells in Vermont.

The work of each group is also intended to contribute to improving the general knowledge and public awareness of naturally occurring groundwater contaminants. The spatial group has demonstrated the need for more testing results and produced a map template for collecting and presenting this essential information. This database of information will highlight areas of concern so that education campaigns can be effectively targeted. The survey group has designed several education strategies, such as pamphlets for doctor's offices and media outreach, based on precedents and the input from survey-respondents. The policy group suggests that language calling for public outreach be included in the bill, such as the Neighbor Notification System. Although our project suggests many ways to teach individuals about arsenic contamination and treatment, it is ultimately up to Vermonters to decide to test their drinking water regularly and to install treatment devices. Undoubtedly, there will be a spectrum of responses. On one end, some may avoid the problem altogether and choose not to test. On the other end, others will take all the treatment precautions available no matter the content of their water. In the end, the goal of this project and policy proposal is to make sure that no one is at a disadvantage due to lack of information or financial resources and that every Vermonter is free to make their own informed decision about their drinking water.

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Appendices

Appendix A. Spatial Data Sets and Methodology

Data sets:

Original Data

- **Mango_data:** data from a professor at Castleton state collected over the past 5 years that only measures arsenic, in UTM Zone 18 (NAD 1983)
- **Taconics_as:** all of the high arsenic Kit C results from the VDH, in State Plane Vermont (NAD 1983)
- **Wells_lte_10_ppb:** all of the Kit C results of less than or equal to 10 ppb from the VDH, in State Plane Vermont (NAD 1983)
- **New_wells:** data from Pete Ryan's arsenic testing throughout Vermont from 2001 to 2009 and from wells tested for arsenic by Arthur Clark and Taylor Smith in January 2010, in UTM Zone 18 (NAD 1983)
- **Max_as_wells_only:** excel spreadsheet that we batch geo-ed to convert into a shapefile, data from Vermont Water Supply Division of the maximum arsenic test result up to 2001 and 2002, in State Plane Vermont (NAD 1983)

Supplement Data

- **Bedrock.shp:** given to us by Jeff Munroe, can be found on VCGI (Vermont Center for Geographic Information) website , shapefile of 9 categories of bedrock types in VT
- **Rutland Kit C:** data from 2004 to present of all Kit C results in Rutland County, includes metals, anions, physicals, and radionuclides in excel spreadsheets that we batch geo-ed to convert into shapefiles
- **Bennington Kit C:** data from 2004 to present of all Kit C results in Bennington County, includes metals, anions, physicals, and radionuclides in excel spreadsheets that we batch geo-ed to convert into shapefiles

Methodology:

Data management

Making the geodatabase

1. Double check defined projections of shapefiles: defined projections of shapefiles should make sense (actually occur in state of VT)
    a. NAD_1983_UTM_Zone_18N files:
        i. Mango_data_2_12_10
        ii. new_wells
    b. NAD_1983_StatePlane_Vermont_FIPS_4400 files:
        i. max_AsWellsOnly
        ii. Taconics_As

iii. Wells_lte_10_ppb

2. Create a Geodatabase. *This geodatabase will contain 5 original shapefiles as feature classes. Using a geodatabase becomes important later when working with the attribute tables: if we merged the multiple shapefiles into a single aggregated shapefile, data points cannot be stored as null values. Using a geodatabase prevents the storage of null data as "0".*
   a. Geodababase named = Well_data_GDB
3. Add data to geodatabase. *Use "Merge" tool to add 5 original shapefiles to geodatabase as feature classes.*
4. Cleanup attribute table of output feature class. *The attribute table of output feature class is the concatenation of the five input attribute tables, so there many fields with similar information that must be combine. (ex. = attribute fields named As_Conc, Arsenic_Con, as_ppb, etc. need to be joined into single field.)*
   a. Open attribute table of output feature class
   b. Create new field for information to be combined (ex = Arsenic_PPB)
   c. Select all rows that have values in one of the similarly named categories (ex=As_Conc)
   d. Open field calculator and set new field equal to field containing specified information for the selected data.
   e. Selected data entries should update in the new field, while values of unselected data entries should equal <null>.
   f. Repeat this process until all fields with similar kinds of information (like arsenic concentration) are combined into single fields.

Processing Kit C data

Edit excel spread sheets

1. Remove & edit entries for which given addresses are the mailing addresses of tester, and not that of the testing location.
   a. Remove entries where the towns given in the two address sections (one for location of well, and one for mailing address of tester) don't match
   b. If testing location address is given in the comments column, copy and paste this address into proper column
   c. If multiple tests record the same property (such as kitchen sink vs. bathroom sink, house vs. guest house), keep only highest result
      i. If entries exist for 2 different *wells* on property, keep both data entries
   d. Remove entries w/ P.O. box addresses
2. Convert arsenic values from mg/L to ppb by multiplying by 1000 (for instance, 0.002 mg/L becomes 2 ppb). Convert values of <0.001 to "0".
3. Change column headings to match those in the existing datasets/geodatabase so that when merged, attributes of data move into appropriate attribute tables (ex = headings for arsenic value columns in input and output files should match).

Batch Geoprocessing

1. Copy contents of excel spreadsheet
2. Past excel spreadsheet contents into "Step 1" box of batchgeo.com homepage.
3. Selected "Validate & Set Options."

- Make sure proper column titles (from header row in original excel spread sheet) are selected for each of the address components

4. Select “Make Google Map”.
5. Once data is geocoded, select “Google Earth KML.” This will download KML file to temporary file on computer.

Google Earth

6. Open downloaded KML file with Google Earth.
7. Wait until all data points are processed and loaded onto Google Earth map.
    - Sometimes a lag in loading data entries occurred, and if we continued to the next step before all points had been located, the output .kml file didn’t have all of the address points.
8. In “places” panel on left side of window, right-click downloaded file. Select “Save Place As…”
    - Save file w/appropriate name in \\splinter\gg_projects\es401 folder. Make sure to save file as .kml file.

ArcMap

9. Start session in ArcMap
10. Open “KML to Layer” conversion tool.
    - Define input KML file from splinter folder
    - Select Output location
11. After all KML files have been converted to feature classes, join data from original excel spreadsheet to new feature classes.
    - Edit original excel spreadsheets to create an “OID” column, with ordinal integers matching appropriate entries in attribute table of feature class.
    - Right-click feature class, select “Joins and Relates,” and then “Join…”
    - Select “Join attributes from a table.”
    - Choose “OID” as field in feature class & in table that join will be based on.
    - Select the obvious table
    - Select “Keep all records.”
    - BE SURE to export the file after joining, to make sure the joined file is saved, by right clicking the file, going to “Data” then clicking “Export Data” then placing it in the correct folder.
12. After all excel spreadsheets have been joined to appropriate feature classes, “Merge” feature classes into single file
    - Merge with the “merged_well_data_as_only” file
    - The newly created file with Kit C data added is now called “Merged_as_plus_kitc”

Analysis & Map Making

Town Stats Layout

Chloropleth map of towns displayed by average arsenic concentration

1. Add data:
    a. Vermont counties layer
    b. Vermont towns layer
    c. Feature class containing arsenic concentration of wells
2. Spatial join: join well data on arsenic concentration to Vermont towns layer
    a. Choose to summarize arsenic concentration by mean/average.
3. Adjust symbology
    a. Open layer properties and select symbology tab
    b. Select arsenic field as value to be displayed
    c. Reclassify ranges as desired.

Locator map of testing counts by town

1. To create map of towns with number of tests:
2. Add Vermont Towns layer
3. Add the shapefile containing spatially referenced wells with arsenic data to the layer
4. Right click on the shapefile's attribute table and add a new field
    a. Use the field calculator to make all values in the new field one (this gives each arsenic reading a value of 1, to be added up to see how many tests were in each town)
5. Right click on the Vermont Town map
6. Click Joins and Relates, Click Join
    a. Select "Join data from another layer based on spatial location"
    b. Choose to join with the shapefile containing wells with arsenic
    c. You should be joining points to polygon
    d. Summarize attributes by selecting Sum
    e. Hit OK
7. Right click on your newly created joined layer and hit properties, then go to the symbology tab
    a. Select the value to be the newly joined sum of tests per town
    b. Reclassify your ranges so they make sense

Testing incidence map

1. Added layer of Vermont counties and state
2. Added data from private well geodatabase edited to just arsenic
3. Classified wells into 0-5ppb, 5-10, 10-50 and 50 and above
4. Set those classes to a color scale to show low to high arsenic wells and areas of concern
5. Copied these layers into 2 extent boxes for Bennington and Rutland Counties
6. Zoomed into to the counties so the boxes contained them
7. Created scale bars for all 3 maps

Bedrock analysis & map
Creating the average incidence of arsenic in each bedrock type map.

1. Inputs =
    a. For Overall Bedrock Map with 9 sub-cats:
        i. Bedrock_dissolve – the bedrock map dissolved so that attribute table represents only the 9 sub-categories
        ii. Merged_as_plus_kitc
    b. For Taconics
        i. Taconic_Allocthons_OrgDis – The Taconic Allocthon rocks feature class that is dissolved based on the original rock-type label (Cbr, Cbrc, Chw, Csc, Cscb, Cscz, Omh, Opa)
        ii. Merged_as_plus_kitc
    c. For Rutland and Bennington Analysis:
        i. Taconic_Allocthons_Rutland_Whole – clipped by Rutland county, then dissolved so all rocks are one polygon representing the Allocthons
        ii. Taconic_Allocthons_Rutland_polygons – clipped by Rutland county, then dissolved so that there are 8 polygon types representing the 8 original rock-type layers
        iii. Bennington_Allocthons_Whole- same for Rutland Whole, but for Bennington
        iv. Bennington_Allocthons_polygons- same as Rutland Polygons, but for Bennington
2. Outputs =
    a. Bedrock_dissolve_SpatialJoin1 – original spatial join with all incidences summed for each sub-category of bedrock and all arsenic values averaged for each sub-category
    b. Bedrock_dissolve_SpatialJoin10 – the percent of wells greater than 10ppb as, the average above 10ppb for each sub-category, and all data from SpatialJoin1
    c. High_as_10ppb
    d. High_as_5ppb
    e. High_as_50ppb
    f. Bedrock_dissolve_SpatialJoin5- the percent of wells greater than 5ppb as, the average above 10ppb for each sub-category, and all data from SpatialJoin1 and SpatialJoin10
    g. Bedrock_dissolve_SpatialJoin50_fin- the percent of wells greater than 50ppb as, the average above 10ppb for each sub-category, and all data from
3. Join Merged_as_kitc (Join Features) with bedrock dissolve (Target Features) using the *Spatial Join* tool:
    a. In field map:
        i. Right-click and set Arsenic_ppb merge rule to “mean”
        ii. Right-click and set Incidence merge rule to “sum”
    b. Creates Bedrock_dissolve_SpatialJoin1
4. Create a file of wells that are higher than 5ppb arsenic:

a. Go to selection tab in file-bar → "Select by Attribute"
b. Select from Merged_as_plus_kitc
c. Write SQL statement to define selection → "Arsenic_ppb" > 5
    i. Select ok
d. Right-click on Merged_as_plus_kitc in the Table of Contents bar
    i. Export data, save to .gdb as high_as_5ppb

5. Join the high_as_5ppb (Join Features) to the Bedrock_dissolve_SpatialJoin1 (Target Features) using the *Spatial Join* tool.
    a. Repeat steps 3a.,3b
6. Add field in the output attribute table "percent_5" that is total incidence/incidence of wells above 5ppb and then multiplied by 100 to give the percent of wells tested in each bedrock zone that is above 5ppb
7. Repeat all steps in 4-6, selecting for 10, then 50 ppb arsenic
8. Final output is Bedrock_dissolve_SpatialJoin50_fin which should have all of the data from each join compiled into the last file

Appendix B. Survey Supplemental Materials

Appendix B.1: Private Well Owner Survey

Date:
Location:
Surveyor:
Town of Residence:

1. Does your water come from a public water system or private well?
   - A public water system (PWS) serves at least 25 people or 15 service connections for at least 60 days per year

2. How many people live in your household?

   A) How many are under the age of 12?

   B) Does everyone in your household drink the tap water?
      a. If no, why not?

3. Do you treat your drinking water in any way?

   A) If "yes"—how do you treat your water and why?
   (Do you use any of the following: a water softener, a reverse osmosis system, a Brita Filter?)

4. Have you ever heard of problems concerning contamination of well water?
   A) If "yes", which and from where?

5. Have you ever had your water tested?

   A) If "yes":
      a. What prompted you to test your water?

      b. How long ago did you test your well?

      c. How frequently have you tested?

d. What tests have you performed?

e. Were the results outside of the range of normal?

6. If your water was found to be contaminated, would you be willing to pay around $500 for treatment?

7. What has discouraged you from testing? (first, give them a chance to respond freely)

A) Please answer True or False for the following statements:

a. It never occurred to me to test. True / False

b. I couldn't find information on how to test. True / False

c. I did not want to pay for testing. True / False

d. I felt that testing would be inconvenient. True / False

e. I am not concerned about the health risks. True / False

f. If I do have a contamination problem, I am worried that treatment will be too costly. True/False

e. I am worried that possible contamination will lower the value of my property. True /False

8. The Vermont Health Department recommends testing your well every year for bacteria and every 5 years for radioactive elements and inorganic chemicals such as arsenic or lead. Were you aware of this?

9. Have you heard of other testing recommendations?

A) If yes, where did you hear about these recommendations?

10. Has your doctor mentioned testing your water?

11. The VT Department of Health would like to better inform the public about their recommendations for private well testing. What would be the best way to deliver this information to you? (e.g. doctors, well-drillers, school, TV, newspaper, website…)

Arsenic in Drinking Water Facts

- Arsenic is a natural element found in some rocks and soil in Vermont. Drinking water wells located in these areas may produce water that contains arsenic.

- Arsenic has no taste or smell. Water must be tested to know if it contains arsenic and at what level. The Department of Health Laboratory and private certified laboratories offer water testing for arsenic. It is recommended that private well owners test their drinking water to learn its arsenic level.

- Ingestion of arsenic over a long period of time has been linked to an increased lifetime risk of getting bladder, lung or skin cancer.

- Owners of private wells with arsenic levels at or above 10 parts per billion (ppb) should consider installing an arsenic removal treatment system, using bottled water, or getting water from a known safe location.

- Arsenic can be removed through a variety of filters. For more information on treatment, visit the Department of Health website.

For More Information

- Department of Health - http://healthvermont.gov
    Technical assistance - 1-800-439-8550
    Laboratory services - 1-800-660-9997

- Department of Environmental Conservation www.vermontdrinkingwater.org
    Water Supply Division - 1-800-823-6500

- U.S. Environmental Protection Agency (EPA) - www.epa.gov/ogwdw/arsenic.html

- National Sanitation Foundation - www.nsf.org/certified/dwtu

- Agency for Toxic Substances and Disease Registry -
    www.atsdr.cdc.gov/toxprofiles/phs.htm

Student Presentation

“Drinking Water from Private Wells – Assessing Consumption and Testing Patterns”
12:15pm December 2, 2010
Franklin Environmental Center at Hillcrest
531 College St./Rt. 125
Middlebury College
Middlebury, VT

Appendix B.3: Physician Interview Questions

Introduction

Hi, my name is ____. I am a college student doing some research on local drinking water, and I'm interested in this issue from a medical perspective. Is Dr. ____ available to answer a few questions? This will take less than five minutes.

If not, when would be a good time to call back? Or, is there another number at which I can contact the doctor?

If she/he is available, wait for the doctor to arrive to the phone and repeat the introduction.

Questions

1. How long have you been working as a physician in the area?

2. During this time, how many times have you dealt with an issue related to contamination in drinking water? From a private well? Related to arsenic?

3. Do you ever talk to your patients about their drinking water?

4. Are you aware whether or not your patients with private wells test their water?

5. You may or may not know that some tests on private wells in your area have shown unsafe levels of arsenic (greater than 10 ppb). Considering this information, do you think it's important that people test their wells?

6. Would you be interested in incorporating safe drinking water education into your office? Through questions during check-ups? Through pamphlets in the waiting room?

7. If you are interested in educating your patients on this issue, in raising awareness of potential contamination of private drinking water, I can tell you more! (Use the fact sheet modified from the VDH website.)

Thank you so much for your time.

Appendix B.4: List of Active Well Drillers in Vermont (2009)

http://www.vermontdrinkingwater.org/wells.htm

Active Well Drillers

First Name	Middle Initial	Last Name	Company Name	Primary Address	Primary City	Primary State	Primary Zip	Primary Phone	Well Driller ID
Clyde (Jack)	W	Frost	Frost Inc	PO Box 455	East Dorset	VT	05253	8006981477	23
Richard		Leise	Richard Leise Well Drilling Inc	RR #2	Argyle	NY	12809	5186388771	37
Prentiss	A	Smith	P A Smith & Sons	2683 Stage RD	Benson	VT	05743-9556	8025374711	40
Richard	L	Stromberg	Green Mt Well Co Inc	PO Box13	Putney	VT	05346-0013	8023875529	53
Larry	W	Benedini	Champlain Well Drilling	14 Sugar Wood Road	Barre	VT	05641	8024799768	66
Ronald	R	Abare	A & W Artesian Well Co Inc	600 Cummings RD	Barre	VT	05641	8024765907	80
Clarence	N	Gould Sr.	Gould & Sons Well Drilling	1704 VT RTE 133	Pawlet	VT	05761	8023253125	93
Thomas	F	Hanson	Hanson Well Drilling & Pump Co Inc	RTE 20 W Box 463	Nassau	NY	12123	5184774127	101
K Sheldon		Beebe		51 Saxton River Road	Bellows Falls	VT	05101	8024633725	140
Bart	C	Cushing	L G Cushing & Sons Inc	PO Box 200	Walpole	NH	03608	8008318883	155
Jeffrey		Cushing	L G Cushing & Sons Inc	PO Box 200	Walpole	NH	03608	6033528866	156
Kim	P	Johnson	E Benedini Artesian Well Co	1 Sunrise RD	Barre	VT	05641	8024764832	161
Jay	F	Wragg	Wragg Brothers of Vermont Inc	PO Box 110	Ascutney	VT	05030	8026745890	162
Gregory		Wragg	Wragg Brothers of VT Inc	PO Box 110	Ascutney	VT	05030	8026745890	163
Daniel		Gosselin	Gosselin Artesian Well Co Inc	PO Box 439	Derby	VT	05829	8027668818	174
Gerald	E	Parker	Parker Water Wells Inc	PO Box 627	East Poultney	VT	05764	8022874016	176
Gerard		Adams	Adams Engineering	47 Blakely Rd.	Underhill	VT	05489	8028994945	185
Claude		Chevalier	Chevalier Drilling Co Inc	PO Box 164	Highgate Springs	VT	05460	8028687709	190
David		Chevalier	Chevalier Drilling Co Inc	PO Box 164	Highgate Springs	VT	05460	8028687709	191
Richard		Purchase	Spafford & Sons	4 Cummings St.	Montpelier	VT	05602	8022237371	165
Michael		Chevalier	Chevalier Drilling Co Inc	PO Box 164	Highgate Springs	VT	05460	8028687709	192
Mark		Chevalier	Chevalier Drilling Co Inc	PO Box 164	Highgate Springs	VT	05460	8028687709	193
Thomas	W	Williams	Spafford & Sons of Williston VT Inc	PO Box 437	Jericho	VT	05465-0437	8028995873	198
John		Holman	John Holman Contracting	PO Box 677	Troy	NH	03465	6032423660	202
Kenneth		Lynde	Lynde Well Drilling	296 Green River RD	Guilford	VT	05301	8002425516	208
David	A	Parker	Parker Water Well	PO Box 627	East Poultney	VT	05764	8022874016	212
George	S	Spear	Ottauquechee Well Drilling	8402 Valley View	Woodstock	VT	05091-8156	8024572530	213
Jeffrey		Williams	Spafford & Sons of Williston VT	PO Box 437	Jericho	VT	05465	8028995873	219
Bruce	R	Meeker	Wragg Brothers of VT Inc	PO Box 110	Ascutney	VT	05030	8026745890	220
Robert		Frost	Vermont Well and Pump	PO Box 510	Hinesburg	VT	05461	8024824235	222
Clarence	N	Gould Jr	Gould & Sons Well Drilling	PO Box 254	Wells	VT	05774		224
David	W	Rosick	Mike Rosick Well Drilling	1175 Farley RD	Hudson Falls	NY	12839	5187460173	230
John	L	Stone	Recovery Drilling Service Inc	PO Box 505	South Barre	MA	01074	9783555100	235
Gary	C	Lynde	Lynde Well Drilling	5392 Hinesburg RD	Guilford	VT	05301	8022545897	237
Arthur	H	Huttemann	Bell Drilling	1531 Upper RD	Plainfield	VT	05667	8024548640	239
Dwayne	E	Feeley	E B Feeley Drilling Co.	4557 Lake RD	Franklin	VT	05457	8029332810	249
John	E	Gould	Gould Well Drilling Inc	644 Townsend RD	Lyndonville	VT	05851	8026264200	252
Darrel	R	Learn	Layne Christensen Co.	PO Box 309	Dracut	MA	01826	9789372242	253
Neal	S	Faulkner	Tri State Drilling and Boring Inc	RR 2 Box 113	West Burke	VT	05871	8024673123	254
Charles	H	Hinsley	Sargent Artesian Well	PO Box 27	Fairlee	VT	05045	8023334720	255
Nick	A	Manosh	H A Manosh Corp	120 Northgate Plaza	Morrisville	VT	05661	8005447666	256
James	E	Carr	James E Carr Well & Pump Services Inc	PO Box 378	Littleton	NH	03561	8005433970	257
Gus	G	Breault III	Gus Breault Jr Well Drilling	118 Stalker Road	Whitehall	NY	12887	5184990587	258
Robert	F	Gordon	H2O Well Drilling	PO Box 2016	Georgia	VT	05468	8025277538	261
Donald	M	Maynard	The Johnson Company	Suite 600	Montpelier	VT	05602	8022294600	262

William	F	Morrissey	Frost Wells & Pumps	262 Rocky Lane	E. Doset	VT	05253	8023624195	264
Gary	D	Butts	Frost Wells & Pumps	PO Box 176	Bondville	VT	05340	8028245874	265
Keith	B	Johnson	E. Benedini Artesian Well Co., Inc.	1 Sunrise Rd	Barre	VT	05641		267
David	B	Myers		PO Box 490	Glenmoore	PA	19346	6109422030	268
William	H	Morrow		2585 Stanton Rd	New Woodstock	NY	13122	3154371429	270
Mark	A	Zork	Technical Drilling Services	PO Box 10	Sterling	MA	01564	9784220005	271
Terry		Swain	Capital Well Co., Inc	150 Concord Stage Rd.	Dunbarton	NH	03046	6037746155	272
Stanley	J	Werbecki	Environmental Compliance Service	588 Silver St	Agawam	MA	01001	8007893530	273
Seth		Pitkin	Stone Environmental Inc.	535 Stone Cutters Way	Montpelier	VT	05602	8022292192	274
Thomas	A	Garside	New Hampshire Boring Inc.	PO Box 165	Derry	NH	03038	6034371610	275
David	J	Nevison	Eastern Analytical Inc.	25 Chennel Dr.	Concord	NH	03301	6034642659	277
Kenneth	P	White	Valley Artesian Well Co.	799 North Runway Rd.	Perkinsville	VT	05151	8022635362	278
Mark	W	Onorato	Frost Wells and Pump Inc.	PO Box 455	East Dorset	VT	05253	8024472281	279
Christopher	D	Aldrich	Specialty Drilling and Investigation	434 Shelburne Rd	Burlington	VT	05401	8026580820	280
Steven	M	Migridichian	Drillex Environmental	127 Hartwell St.	Boylston	MA	01583	5088358822	281
Victor	R	Stork	Stork's Well Drilling	53 Pollards Mills Rd.	Newport	NH	03773	6038634291	282
Scott	A	Hollabaugh		52 Elm St. Bay 1	Manchester	NH	03101	6036459400	283

Available for download from the Vermont Department of Environmental Conservation's (DEC) Water Supply Division:

Questions

1. Do you initiate any conversation with your clients about groundwater quality and potential contamination?

    If yes, what does that entail?

2. Are you familiar with the Vermont Department of Health's recommended well water testing strategy? If so, do you share these recommendations with your clients?

3. Do your clients express concerns about specific contaminants?

4. What groundwater contaminants are you most aware of and concerned about?

5. Are you aware that some private wells in Vermont have elevated levels of naturally occurring arsenic, due to arsenic-leaching bedrock formations?

6. Do you think there is certain information all well drillers should provide to their clients?

Appendix B.6: Recommendations for Improved Education and Outreach

Recommendation #1: Improve the VDH Website

Currently, the VDH relies almost exclusively on its website to distribute water-related health information. The online "Safe Water Resource Guide" serves as a gateway to the VDH's available information on a host of drinking water quality topics, and is easy to find using a general search engine or by following links from the VDH home page. The Safe Water Resource Guide is a great and user-friendly resource. A link for "Testing Your Water Supply" is displayed prominently at the top of the page (Figure 1).

Safe Water Resource Guide

- Testing Your Water Supply
- Private Sources of Drinking Water
- Radioactivity in Water Supplies
- Volatile Organic Compounds (VOC's) in Drinking Water
- Fact Sheets and Additional Information
- Government Resources

Figure 1: Water testing link at the top of VDH's Online Safe Water Resource Guide. [http://healthvermont.gov/enviro/water/safe_water.aspx]

This link takes the user to a fantastic webpage with well-organized information about how to test, followed by a very appropriate overview of water quality concerns. However, under the heading "Concerns related to specific chemicals found in drinking water," the descriptions for lead, arsenic, nitrate and hardness need to be hyperlinked to the appropriate VDH specific contaminant fact sheet (Figure 3). These links can be found on the main "Safe Water Resource Guide" page (Figure 2), but they should also be included here.

Fact Sheets and Information

- Arsenic and Drinking Water
- Monochloramine
- Facts about Coliform Bacteria in Water
- Lead in Drinking Water
- Nitrates/Nitrites
- Disinfection of Drinking Water - Instructions for making water from a spring or well of unknown quality safe to drink on a temporary basis.
- Hardness in Drinking Water - There are no known health risks associated with the consumption of hard water, but hard water can cause other problems.

Figure 2: Hyperlinks to Fact Sheets on VDH's Online Safe Water Resource Guide. [http://healthvermont.gov/enviro/water/safe_water.aspx]

Concerns related to specific chemicals found in drinking water:

Arsenic
has been linked to increased lifetime risk for bladder, lung, or skin cancer. Potential links between arsenic and cardiovascular disease, diabetes and other cancers are being studied, but the evidence to date is not conclusive. The maximum level for arsenic in water is 0.010 milligrams per liter (mg/L).

Chlorides
do not cause health problems, but high chloride levels in drinking water may be a sign of other problems. For example, road salt can contaminate water supplies causing chloride levels to be high. High levels of chlorides in drinking water may also give water an unpleasant taste. The maximum level for chlorides in water is 250 mg/L.

Copper
is an important mineral for the formation of red blood cells. However, high amounts of copper in water can cause stomachaches, vomiting, or diarrhea. Young children are more sensitive to high levels of copper than adults. Water with large amounts of copper can stain plumbing fixtures and give the water a metallic taste. The maximum level for copper in water is 1.3 mg/L.

Hardness
causes no known health risks. However, very hard water can cause reduced lathering of soap, and buildup of scale in water heaters, cookware and plumbing fixtures and valves. No limits are established for water hardness.

Iron
is an essential element and does not generally cause negative health effects. However, in large quantities it can cause staining of clothing, sinks, toilets and bathtubs. As with copper, iron can give water a metallic taste. The maximum level for iron in water is 0.3 mg/L.

Lead
is a highly toxic metal that can cause serious health problems, especially for infants, children, and pregnant women. Nervous system, kidney, and red blood cell problems may be effects of exposure to high lead levels. In young children, lead may have harmful effects on nervous system and brain development. Lead has been used in making solder, fittings and fixtures found in household plumbing. The maximum level for lead in water is 0.015 mg/L.

Manganese
does not cause health problems at levels typically found in drinking water and it is an essential element for human metabolism. However, manganese can discolor water; stain clothing, sinks, toilets and bathtubs; and can cause undesirable tastes in drinking water. The maximum level for manganese in water is 0.050 mg/L.

Nitrate
in elevated levels is linked with two known health problems: Methemoglobinemia or "blue baby syndrome" is caused by an oxygen deficiency in the blood. This causes bluish skin tone in infants. In adults, nitrates can form chemicals called nitrosamines that have been linked to cancer. These may pose long-term health risks. Elevated nitrate levels in well water may also indicate other problems such as contamination from sources such as septic systems or fertilizers. The maximum level for nitrate in water is 10.0 mg/L. However, when levels exceed 5 mg/L, the source of nitrate should be investigated.

Figure 3: Section of contaminant list from VDH's Online Testing Your Water Supply guide (topics requiring hyperlink circled by author). [http://healthvermont.gov/enviro/ph_lab/water_test.aspx]

The arsenic fact sheet page [http://healthvermont.gov/enviro/water/arsenic.aspx] provides a good framework, but needs to be updated and expanded. The "Exposure" section places too much emphasis on the generally insignificant forms of arsenic exposure (fossil fuels, pesticides, food) (Figure 4). These less important forms of exposure are bulleted, implying an emphasis on those examples and drawing attention away from the first and only sentence that mentions ingestion of contaminated water. In reality, the real concern for arsenic exposure is ingestion over a long period of time by means of a contaminated drinking source. We recommend the following revision:

Exposure (Proposed Revision)
Drinking water with high levels of arsenic over a long period of time is the main and most dangerous source of exposure to arsenic. Contaminated water is only dangerous if ingested, and can be used for bathing. ***There is little evidence that watering with contaminated water will effect levels of arsenic in food grown in your garden.*** Very low levels of arsenic are naturally found in some foods, mainly seafood and fish, and in some industry products, included pressure treated wood, fossil fuels, and pesticides. Periodic exposure to these products does not pose health risks.

Figure 4: Proposed revision for the "Exposure" section in the VDH Online Arsenic Fact Sheet. [http://healthvermont.gov/enviro/water/arsenic.aspx]

The "Treatment" section of the arsenic fact sheet is also somewhat out of date [http://healthvermont.gov/enviro/water/arsenic.aspx], and would benefit from more detailed information about price-range, and point-of-use vs. point-of-entry systems.

Treatment (Proposed Revision)
Arsenic is soluble, and does not accumulate in the body like some contaminants (e.g. mercury). This is good news because if you have been ingesting arsenic in your drinking water, it will likely only take a few days of drinking pure water to clear all the arsenic from your system and eliminate further risk of adverse health effects. Arsenic levels can be reduced in drinking water with treatment. However, many common treatment systems like water softeners, carbon filters, and sediment filters do not effectively remove arsenic from water. There are two types of treatment systems available for arsenic removal: "point-of-use" and "point-of-entry" systems. Point-of-use systems treat a single faucet that is used for drinking and cooking. Point-of-entry systems treat all the water entering a house. Point-of-use systems are generally recommended because they are less expensive and can easily treat enough water to drink and cook with.

Treatment (proposed Revision, cont.)

The following treatment options can be used to remove arsenic from water. However, after a treatment system is installed, a follow-up sample of the treated water should be tested to make sure arsenic levels are below the approve standard of 10 ppb.

Absorptive Filters - Arsenic naturally absorbs (sticks) to iron, so filtration systems containing a type of granular iron oxide are an effective, and generally cost effective ($300 - $500 for Point-Of-Entry systems), means of arsenic removal. The iron media needs to be replaced periodically and disposed of.

Reverse osmosis - Reverse osmosis is a common treatment option, generally chosen as a treatment for one household tap, typically the kitchen tap. This technology uses home water pressure against a thin membrane, allowing only arsenic-free water to travel through. The membrane is continually rinsed. The average installation cost is between $300 and $700 dollars, with $0.33/day average maintenance costs. The typical media life is about 3 years and maintenance is minimal.

Anion exchange - Anion-exchange systems exchange arsenic compounds for chloride using a specialty resin. When the resin is saturated with arsenic, a pump rinses the resin (using a backwash cycle) and sends the arsenic down the drain. This system produces high amounts of waste and requires complex maintenance. The average installation cost is around $2000 dollars with a $0.27/day maintenance cost. The typical media life is about 10 years.

Countertop (plug-in) - Distillation units boil water and then the steam is condensed. These units can produce several gallons of arsenic-free water per day. It is important to note that arsenic is a metal and merely boiling water will not remove it. The average cost is around $300, with a $0.40/day maintenance cost. The typical media life is about 5 years.

Carbon block -This technology can reduce total arsenic as the water passes through a solid carbon block. Look for National Sanitation Foundation Standard 53 Certification, which verifies that the filter's arsenic reduction claim has been confirmed.

Figure 5: Our Recommendation for a new "Treatment" section in the VDH Arsenic Fact Sheet. [http://healthvermont.gov/enviro/water/arsenic.aspx]

Recommendation #2: Create an Informational Pamphlet on Arsenic for Vermont

The VDH does not have a pamphlet with information about naturally occurring arsenic and private well testing. Most states with arsenic contamination issues have a printed arsenic pamphlet or fact sheet. A number of sample pamphlets and fact sheets have been reviewed, and are included and referenced on page 85. We have taken the most effective elements of these samples and developed a prototype pamphlet that may be either used or adapted by the VDH. Important organizational features include the Q & A format and a tri-fold layout. Key topics include:

- What is arsenic?
- How much is too much?
- What are the health risks?
- Should I get my water tested?
- How is arsenic removed from drinking water? and
- How can I learn more?

These pamphlets can be distributed to schools, doctors offices, well drilling companies, town offices, and health department offices both to provide awareness and disseminate important information about the problem of arsenic in private wells, and the relative simplicity of the solution.

How Can I Learn More?

Vermont Department of Health
108 Cherry Street
Burlington, VT 05402
802-863-7200 or 800 464-4343
healthvermont.gov

Vermont: Safe Water Drinking Guide
healthvermont.gov/enviro/water/safe_water.aspx

Vermont: Arsenic in Drinking Water
healthvermont.gov/enviro/water/arsenic.aspx

Vermont Department of Health Laboratory
To request/return a test kit
195 Colchester Avenue
PO Box 1125
Burlington, VT 05402-1125
802-863-7335 or 800-660-9997

United States Environmental Protection Agency
Information on Private Wells
water.epa.gov/drink/info/well

County Health Offices

Addison County
888-253-8804 or 802-388-4644

Bennington County
800-637-7347 or 802-447-3531

Caledonia County
800-952-2936 or 802-748-5151

Chittenden County
888-253-8803 or 802-863-7323

Franklin County
888-253-8801 or 802-524-7970

Lamoille County
888-253-8798 or 802-888-7447

Orange County and the Upper Valley
888-253-8799 or 802-295-8820

Orleans County and the Northeast Kingdom
800-952-2945 or 802-334-6707

Rutland County
888-253-8802 or 802-786-5811

Washington County
888-253-8786 or 802-479-4200

Windham County
888-253-8805 or 802-257-2880

Windsor County
888-296-8151or 802-885-5778

ARSENIC and your Private Well

Arsenic has been detected in groundwater wells in many regions of Vermont at levels that may have serious health impacts.

Have you had your well tested for Arsenic?

What is Arsenic?

Arsenic is a natural element found in some rocks and soils in Vermont. Drinking water wells located in these areas may produce water that contains arsenic. Arsenic has no taste or smell. Water must be tested to know if it contains arsenic and at what level. Call your local health officer to find out more about arsenic in your area.

How Much Arsenic is Too Much?

The federal standard for arsenic in public drinking water was 50 parts per billion (ppb) for decades. Recently, the U.S. Environmental Protection Agency announced a stricter and more health protective standard of 10 ppb. Owners of private wells with arsenic levels at or above 10 ppb should consider installing an arsenic removal treatment system, using bottled water, or getting water from a known safe location.

What are the Health Risks?

Health effects due to drinking water with arsenic depend both on the concentration of arsenic and the length of exposure to the contaminated source. Ingestion of arsenic over a long period of time has been linked to increased lifetime risk of bladder, lung and skin cancers. Research is ongoing on arsenic's links to skin and cardiovascular diseases, diabetes, and other cancers.

Should I get my water tested?

The Vermont Department of Health (VDH) recommends that private residential wells test for inorganic chemicals, including arsenic, every 5 years. The Vermont Department of Health Laboratory Kit C test ($100) checks contaminant levels for all inorganic chemicals. You can also request a test just for arsenic ($12). Testing forms can be found on the Vermont Department of Health website, or you can call the state laboratory

VERMONT
DEPARTMENT OF HEALTH

What Can I Do to Remove Arsenic From My Water?

Using water softeners, chlorine shots, water-pitcher filters, or boiling water will NOT remove arsenic from your drinking water. Arsenic removal requires a more specialized filtration system.

There are two main categories of treatments systems. Point-of-Entry systems treat all the water that enters your house. Point-of-Use systems typically go under the kitchen sink and treat that particular tap to provide safe drinking and cooking water. Since arsenic is only a health problem when it is ingested in elevated concentrations over time, a Point-of-Use system is quite sufficient. Point-of-Use treatment systems range from $300-$700, with average maintenance costs of $0.30/day. Option include reverse osmosis, iron filters, and anion exchange systems. More information and guidance about arsenic treatment options can be found on the Vermont Department of Health website, or the US EPA website.

Annotated Bibliography of Sample Pamphlets

[1] <u>United States</u>
6-page excerpt from 24-page Arsenic Pamphlet released by the American Ground Water Trust (full pamphlet available for $0.50 - $0.70 each). 2pp Background; 2pp Health; 2pp Testing; 1p POE vs POU; 9pp Treatment Methods; 2pp For More Information.

[2] <u>BC, Canada</u>
8 ½ x 11 (double sided) "Arsenic in Groundwater" pamphlet; part of the Water Stewardship Information Series released in 2007 by the BC Groundwater Association.
<u>PROS</u>: Q&A, large print headings, discusses geography, clearly part of a series
<u>CONS</u>: Focus on acute health effects, little about treatment, includes confusing standards

[3] <u>Wisconsin</u>
Quatri-fold 8 ½ x 14 (double sided) Fact Sheet released by WI Dept of Natural Resources and the Bureau of Drinking Water and Groundwater
<u>PROS</u>: Focus on arsenic, the standard, testing, extensive more-information section, includes basic county-by-county map
<u>CONS</u>: Little about health effects, treatment section vague

[4] <u>Illinois</u>
3 page Q&A factsheet released by the Illinois Department of Public Health
PROS: Focus on exposure and health risks, lists how they obtained funding
CONS: Explains how to test, but not clearly, doesn't even mention treatment

[5] <u>Arizona</u>
8 ½ x 11 tri-fold brochure (double sided) released by AZ Dept. of Health Services
<u>PROS</u>: Q&A format, large print Divides the standard into **<u>GREEN</u>** (<10ppb, you're fine), **<u>YELLOW</u>** (11-200ppb, don't panic, health effects are chronic, look into a clean water source and/or treatment), and **<u>RED</u>** (200ppb+, stop consuming immediately)
<u>CONS</u>: Very little detail, though Health Dept. contact info is provided.

[6] <u>New Jersey</u>
2-page document released by NJ DEP and NJGS in 2007
<u>PROS</u>: 1 ½ pages comparing treatment options, including a very useful chart, and recommended treatment options
<u>CONS</u>: Only a very brief paragraph about arsenic and arsenic testing, they recommend Whole-House over Under-Sink systems, and Granular Ferric Adsorption over Reverse Osmosis. We don't necessarily agree.

Recommendation #3: Implement a Media Outreach Plan

The vast majority of Vermonters surveyed listed media outreach as the best way for the VDH to reach out to the public with information about groundwater contamination and testing options. There are numerous examples of media outreach in New England and throughout the country that demonstrate the many ways that the media can support private well testing education. We have developed a Media Outreach Action Plan for Private Well Testing Education based on our research.

VDH Media Outreach Action Plan for Private Well Testing Education

Media outreach is most effective when it is relevant to current public events. Information about testing recommendations for private wells can be incorporated into a myriad of related news events and articles. The VDH will be proactive in providing local, regional, and statewide papers and news stations with information for media publication, with the request that any resulting article or news special contain a statement about recommendations for private well testing, and a clear description of how to request a private water test. (Please refer to the adjacent pages to view summaries, full text of referenced sample articles will be provided to the VDH)

- When the result of a town's municipal water test is released [1, 2].
- When the VDH or VGS discovers a new trend in testing results, geology, health etc., if it relates to ground, surface, or drinking water in any way [3, 4].
- When important legislation is up for discussion in Montpelier, the VDH should contact the media and encourage coverage of the issue [5 - 7].
- Many local papers have popular "blurbs" sections, which allow contributors to share information efficiently with their communities. A quick "have you tested your water, here's how!" blurb could be quite effective [8].
- A week or month-long testing blitz or education push will be attractive to the media and encourage people to take care of testing *now* [9].
- Engage and encourage public interest. The VDH is not in a position to enlist journalists to work on public interest pieces related to drinking water quality. However, the VDH should respond to any and all media related to drinking water quality, with a letter to the editor thanking the publication for their interest and providing information about any questions raised, and about testing recommendations [10-13].
- Even without a specific reason, issuing periodic press releases about private well testing can make an impact. Often more substantial articles will come out of persistent interaction with the governmental agencies [14-16]

Annotated Bibliography of Cited Articles

[1] Aug 2010, US State News, Reasnor IA, *Drinking Water in Reasnor May Be Safe Depending on Source*
Post results of recent town water tests, alert residents that boiling water *increases* concentrations of nitrates, warnings about specific areas and weather conditions that may indicate high risk. Includes contact information.

[2] Jul 2004, The Record, Bergen County, NJ, *Water System Gets Sparkling Evaluation; Ringwood Grateful for some Good News*
Published after local municipal water system in Ringwood, NJ was tested. Discussion of local drinking water issues. 1/3 of local residents rely on private well water, and are encouraged to test. The League of Women Voters of Ringwood released a "Know Your Water" brochure to educate residents about what might be in their water.

[3] Apr 1999, Portland Press Herald, Maine, *State Urges Testing of Wells for Arsenic; Stricter Drinking Water Standards are Recommended as New Research Bolsters the Link Between Arsenic and Cancer*
Front-page article released just before a standard change for safe levels of arsenic, and after a study about arsenic and cancer-risk. Post-change, estimates show that 25% of private wells in Maine may be contaminated with Arsenic. Message: BIG ISSUE, EVERYONE SHOULD BE CONCERNED; EVERYONE NEEDS TO TEST THEIR WELL. Includes a discourse on the history of arsenic contamination, standards, health risks, and science – all with the end message of TEST YOUR WELL.

[4] Jun 2000, Owen Sound Sun Times, Ontario, Canada, *Water Tests Flood Health Unit*
In the wake of E. coli scare, health unit brings in 150 tests per day from concerned residents, and has everyone talking about water quality.

[5] Mar 2004, The Philadelphia Inquirer, South Jersey Section, *New State Test Flags 8 Percent of Private Wells; In it's first year, the health program checked 5,179 before home sales, Most failures were due to nitrates*
8% private wells tested in first year of new bill were over the safe limit for bacteria and chemicals (mainly nitrates). Includes breakdown by county of most impacted areas. Refers to funding for treatment related to mercury & VOCs. Explains the new program, and claims that after a year it is clear that the program was needed and successful. Unsure if the program influenced the housing market.

[6] Dec 2001, Providence Journal-Bulletin, RI, *Bierman to Reintroduce Bill Requiring Tests of Private Wells*
Bill would require testing of private wells before their first use and during any property transfer. Outlines requirements of the bill, and its status.

[7] Sep 2000, Hamilton Spectator, Ontario, Canada, *Bradley Urges Clean-Water Law; McMeekin Vows to Fight for Improved Water Testing*
In wake of E. coli scare, candidates promise to address drinking water quality. Mainly

focused on ramping up quality standards, cracking down on zoning, and creating a Clean-Water Act

[8] May 2002, Chicago Daily Herald, *BRIEFS: It Just Got Cheaper to Test your Well Water*
County Health Officials reduce testing cost from $14 to $10 for 10 days (no one is turned away). Less than 100 words, includes testing and contact information. Part of a "BRIEFS" section.

[9] Mar 2007, US State News, Concord, NH, *New Hampshire Department of Environmental Services Encourages Measures to Protect Groundwater*
Recognizes National Groundwater Awareness Week (mid-March). Some statistics (40% of NH residents rely on private well water). "Groundwater protection is easy, here's what you can do" – followed by bullet points on how to prevent contaminating your own water source (and others) and on conservation. Contact information and website provided.

[10] Sep 2006, St. Louis Post-Dispatch (Missouri), *Thousands Drink From Unregulated Wells*
Public interest piece about the phenomena of unregulated private drinking water. Good background information, and actually helpful information about how to test, who to talk to, and how much it will cost.

[11] Nov 1982, The New York Times, CT Section, *Testing to Protect Private Wells*
1500 word interest piece on the front page of the section talking about the growing number of people who test their wells, speaks generally to issues of pollution, interviews a few testing labs. Seems to be in response to a recent study. Refers to mapping projects to identify "red flag" areas of the state. Focus is on anthropogenic.

[12] Jun 2006, The Philadelphia Inquirer, *Ask… the Green Action Alliance chairman*
Q&A with local NGO, briefly cites the issue of private well testing as something they work on, as part of working on general water contamination issues.

[13] Feb 2001, New Hampshire Sunday News, *(Water Under Pressure) Arsenic on tap. Arsenic: Where it is How It's Used*
Concern about arsenic introduced via fluoridation in public and private water supplies. Includes overview of arsenic in NH (15% of wells contaminated, DOH urges testing), of health risks, treatment options, changes in the standard

[14] Nov 2001, PR Newswire, Financial News, Concord, NH, *New Hampshire Citizens Encouraged to Obtain Information About Water Quality and Arsenic; Experts in Arsenic Removal Stand Poised to Offer Information and Solutions as the EPA Finalized the New Arsenic Standard*
Overview of private well issue (35% of population relies on private well water), mentions the standard change. Includes a literature review connecting cancer and arsenic, data about willingness to test and treat (9/10 Americans express concerns about their drinking

water, 65% would pay to treat it – from 2001 National Consumer Water Quality Survey), offers contact information for a local firm with water treatment and testing services.

[15] Jul 2008, US States News, Springfield MO, *Well Water Testing Recommended Annually*
Press Release from Springfield-Greene County Health Department, encourages annual testing for bacteria and viruses. Includes information on testing, including specific prices for standard and extra tests.

[16] Jul 2010, US Federal News, Colombia, *Check the Safety of Your Well Water*
Recommends that private wells should be tested annually for bacteria, references a factsheet to be found online.

Recommendation #4: Educate the Public by Educating Our Children

Part A: Engaging Youth to Spread Awareness about Contamination Issues

An effective way to educate Vermonters on this public health issue would be to use the education infrastructure already in place – schools. Educate students in a creative way that inspires them to embrace the topic and bring it home to their family. Because children are particularly sensitive to contamination, their awareness is important. Plus, we should not underestimate children's capacity to influence behavior. Parents will have a difficult time refusing their child's request to test the drinking water. The strategy of educating and empowering students on health problems caused by household contaminants is not unprecedented.

Lead poisoning is a similar issue to arsenic contamination. Lead is a toxic metal that was used for many years in products found in and around our homes. Lead may cause a range of health effects, from behavioral problems and learning disabilities, to seizures and death. Children six years old and under are most at risk (www.epa.gov/lead). High school students in Dorchester, Massachusetts took part in a sixteen-week project called the Codman Square Lead Initiative. The tenth grade students researched the history of lead and the impact of lead poisoning on human development. Students collected soil samples from the Codman Square neighborhood and submitted the samples for testing at the Environmental Protection Agency Lab in Lexington, Massachusetts. In response to the detailed lab results, the students were then required to disseminate the information to their local neighborhood.

A similar project took place in New Orleans after Hurricane Katrina. This project dubbed the Fundred Dollar Bill Project was a nationwide drawing and teaching project designed to raise awareness of the environmental threat of lead contamination and to engage people through making art. In addition to awareness, the project was designed to raise money for cleaning up lead contamination. Children, educators, families, churches, and community groups were instructed to create their own version of a $100 bill using a common template. These Fundred dollar bills were picked up by a special armored truck, and then presented to the U.S. Congress in an a conceptual exchange for real dollar funding to be directed to making the lead-polluted soils in New Orleans safe.

Radon is another common household contaminant that is not easily detectable through site or smell. It is also a serious risk to public health and is the number one cause of lung cancer among non-smokers (www.epa.gov/radon/healthrisks.html). In 2009, the National Safety Council and the EPA sponsored a National Radon Poster Contest. Any children, ages 9-14, were eligible. This included students who are enrolled in a public, private, territorial, tribal, or home school, or were sponsored by a club, such as an art, computer or science club. The national winner, a parent and a teacher (or sponsoring organization's representative) won an all-expenses paid trip to our nation's capital where they participated in an awards ceremony. The intent was to reproduce the poster and distribute it nationally to promote radon awareness (www.nsc.org).

This contest idea can be replicated at the state or local level. For example, the East Central District Health Department of Nebraska is currently conducting a local radon poster contest for students. A contest could also encourage other types of creative skills. This year the American Lung Association in Illinois (ALA-IL) and Illinois Emergency

Management Agency Radon Program (IEMA) along with University of Illinois Extension Office, Respiratory Health Association of Metropolitan Chicago, and the U.S. Environmental Protection Agency Region 5 are hosting a state-wide radon video contest. The videos should be designed to increase awareness and encourage people to test. The school corresponding to the winning video will receive $2,000 in prize money for curricular activities. An additional $1,000 prize will be awarded to the class or individual who created the video.

All of these education campaigns offer different strategies for raising awareness. The Codman Square Lead Initiative is particularly effective because the students learn how to take samples and have them tested. Furthermore, requiring the dissemination of information to neighbors is an efficient method to share information. The Fundred Dollar Bill project had the added bonus of raising money to help remove the contaminant. The poster and video contests promote creativity and teamwork, and the awards provide incentive to participate. The Vermont Health Department could use any or all of these strategies to engage young people and make a successful arsenic education campaign.

Part B: Private Groundwater Week

Another potential approach for the Vermont Department of Health would be a week-long education campaign that focuses on drinking water, targeted in particular at families and children. The American Water Works Association (AWWA) sponsors a National Drinking Water Week every year which the VDH could model its campaign after. The AWWA focuses on public water supply systems; however, the VDH could adjust the events to focus on private well-water, testing, and treatment. The AWWA suggests that a community's Water Week include daily press releases (Monday through Friday), handouts provided at community events, children's activity pages (coloring or crossword puzzles), artwork posted throughout town, proclamations given by town officials—such as the mayor, public service announcements, and the use social media such as creating a Facebook group. All of these outreach strategies would supplement daily public events.

We suggest that each day have a theme so that the Private Well Water Week looks like the schedule listed below. Posters and a Facebook event would announce the week's events. The press release for each day should be included on the front page of the town newspaper as well as the town website. The children's activity pages would be distributed to schools before the start of the week so that each day classes could spend a short-time completing the activities. Older students, such as those in high school, may be required to write a creative essay on private well water covering one or all the themes of the week. They would be invited to submit their essays into a contest of which the winner would be announced at the end-of-the-week celebration.

Monday—Construction of Wells and Variation in Water Composition

- The press release, handouts, and children's pages focus on the science behind water composition and how it varies.

- An after school and work public event is held to mark the start of water week. The mayor is invited to make a speech on the importance of a clean water supply for all.

Tuesday—Health Effects of Contamination

- Outreach focuses on health effects of each contaminant for which the VDH recommends testing.
- A local health official, or someone who has personally been affected by contaminated water, speaks about the potential health effects.
- Free bottled water is offered to the audience in conjunction with the distribution of handouts.

Wednesday—Testing Private Wells

- Outreach focuses on the VDH recommendations for testing and the logistics of getting a well tested—where to get the test kit, the testing options with prices, and where to drop off the sample.
- A local well-driller speaks about their experience with private wells—construction, contaminants, and testing.
- A limited number of discounted Kit-C test kits are given on a first-come, first-serve basis to households with a child of 12 years or younger.

Thursday—Treatment of Private Wells

- Outreach focuses on the logistics of treating—the treatment options with price and where to buy the equipment.
- The town invites vendors of treatment equipment (such as reverse-osmosis filtration systems) to set up booths at a publicly-visible location—outside the town hall or a major grocery store.
- Current users of treatment equipment are asked to open their homes to fellow town members so that those interested can see what the equipment looks like and to ask questions.

Friday—Celebration

- The town holds a water celebration. This may include a music, food and beverages. (The AWWA encourages towns to submit a video of their water celebrations. This video can be entered into a contest to win $1000 to be used at the AWWA bookstore.)

- A “Water Olympics” is held for kids including activities such as water balloon tosses.

- The mayor gives a short speech on the significance of the week. Mayor announces winner of essay contest.

The goal of the Private Well Water Week is to focus as many resources as possible on the issue in a short amount of time. This concentration of effort from the VDH and town officials is an effective way to reach a majority of the population through at least one venue and hopefully more. With a bombardment of information, it is practically impossible for anyone to escape without some form of raised awareness. The key is to establish a baseline of informed citizens who will then serve as a resource to their neighbors and friends. Kids in particular should be encouraged to bring their work home to share with their families. This will likely lead to important conversations initiated by children within their homes.

Appendix C. Policy Group

1. Personal Narrative from Laurel and Bjorn Coburn

As written by Laurel Coburn

Healthy & happy

Before our son got sick, he was a cheerful, active kid!

Before getting sick. Happy boy!
Cornwall, October 2008 (2 years 11 months old)

Cheerful and happy.
Cornwall, October 2008.

We lived in Cornwall, Vermont until our son was about to turn three years old. Then we moved three miles down the road to my parents' house in Whiting, Vermont.

Getting sick
Shortly after the move to the new house, Bjorn started having serious behavior problems (screaming for hours a day) and a rash. This continued for several weeks.

Then we made a week-long trip out of state, in which his rash healed and he was happy and cheerful. That was the last time we saw him healthy and cheerful for months.

When we returned to Whiting, his rash came back. A few weeks later, he got sick. He vomited, had frequent diarrhea, was disoriented, lethargic, cold, pale, and dehydrated. He became dull, quiet. He refused to eat and we had to force him to drink water (we knew that if he was sick, the best thing we could do was to make sure he drank plenty of wonderful well water!). He had trouble standing. He had difficulty speaking and his former loquaciousness was replaced with fragmented, failed attempts to speak: "I…." Silence. Later: "The…." Silence.

This was the first period of being violently ill. It lasted 3-4 days. It was so strange that I took him to the doctor. We began blood tests to understand what was happening.

This violently ill period was followed by a month-long period in which he was fatigued. He was tired and vague, ate only simple foods (oatmeal and fruit), and slept hours more a day than usual. During these times, he would sit and eat and then wait until he was moved elsewhere, and had little energy to show interest or joy.

Eating and staring blankly ahead
Whiting, November 2008


Bjorn sitting with his mom. We are all tired.
Whiting, November 2008

For three months, he followed a cycle: violently ill for 3-5 days/month. The remainder of the month he was dull and tired.

Developmental halt

During these months, Bjorn started to learn to count but otherwise made no developmental gains. In fact, he actually regressed developmentally! He stopped hopping, dressing himself, climbing, joking, asking questions, and was less intense. He acted atypically: didn't remember details, disoriented, didn't want to go anywhere (usually was always restless), wanted same books over and over (since birth has always liked to read books only once), wanted simple and cozy books about Sesame Street rather than funny, ironic, scary, complex books. He was not excited about interesting new events.


Looking at Christmas horse-pulled carriage with apathy (held by Dad)
Burlington, November 2008

Visiting the doctor and hospital lab…again…and again

We engaged in a good deal of lab work to figure out what was wrong. It was not clear and a good deal of testing occurred. At least our son learned a new word: a "phlebotomist" is a person who draws blood! A pediatric phlebotomist is someone who knows how to draw blood from a small kid.

Better on a trip away from home

In late December, Bjorn was much more alert and active when we visited Atlanta. He could walk longer distances and played with ideas a bit more than he had been. But when we returned to Whiting, he became sick again.

We noted that he was healthier when traveling away from home. We looked for environmental causes. We tested the drinking water but found no elements above the EPA limits.

Arsenic levels

As he entered another violently ill phase, we took another look at the drinking water. The only even slightly elevated level in the water test was arsenic. At 6 ppb, it was below EPA level of 10 ppb. However, we learned that the EPA has originally proposed 5 ppb as a safer standard (http://72.32.110.154/media/pressReleases/010628.asp). And we learned that 3 ppb was recommended by the Natural Resource Defense Council (NRDC) (see their February 2000 report at http://www.nrdc.org/water/drinking/arsenic/aolinx.asp). We later retested the water; the arsenic was measured at 14 ppb. Although this level of arsenic is not thought to make someone as sick as our son was, we figured we might as well take him off the water and see if it helped at all.

Recovery

Day 1: On January 11, 2009 we stop giving Bjorn the tap water in Whiting and replaced it with bottled water. This is during one of the "very sick" periods, and he continued to be sick the rest of the day (9 diarrheas that day). He was listless.

Day 2: Bjorn starts to feel better and starts to drink. He can now walk a few steps. He became cheerful. However, he was still confused and disoriented. He didn't talk.

Day 3: Bjorn seemed on the low end of his "normal" for the first time since mid-November! He was hungry, hopped, talked and joked, laughed, ran, played with ideas, and was loud & demanding.

Day 5: Bjorn started to undress and dress himself again, and began climbing again. In subsequent days and weeks, he regained his physical stamina and energy level!

He's standing and walking again!
Whiting, January 2009

Diagnosis

After seven weeks on bottled water, we were thrilled to see our son recovering. At the same time, we were deeply disturbed that he had not yet fully recovered. And we continued to be confused about the cause of his sickness.

We took him to the Pediatric Environmental Health Clinic at Children's Hospital in Boston. They concluded that it was arsenic poisoning that caused the decreased developmental milestones. They said that it would take a few months to see how complete his recovery would be.

The effects of lower levels of arsenic, especially on children, is poorly understood. The levels in my parents' well would increase adults' risk of developing cancer after 10 years of drinking the water. My son was like the canary in the coal mine.

Removing arsenic from the water

We didn't want to rely on bottled water forever! So we called the Culligan man to learn how we could clean the arsenic out of the well water. We learned that a whole house system that would remove arsenic would cost about $4,000. This cost was prohibitive for us.

My Dad researched under-the-sink systems for cleaning water and hired a plumber to install the new system, which was significantly cheaper (details of costs are provided in the following section).

However, Bjorn also had a solution to this problem! Bjorn built a pipe system that could pump “water with NO arsenic” from an imaginary, clean well directly into the bathroom tap!


Bjorn, feeling better, works on his new, cleaner water system.
Whiting, May 2009

Full recovery
Five months after the recovery began, our son again had the same physical and mental abilities that he did before he became sick. He had a rough eight months developmentally, but Children’s Hospital told us to immerse him in a rich learning environment to help him catch back up. He is happy and alert now! We are so thankful!

Happy and playing at a friend’s medical school graduation. At our friend’s apartment, he created a “radio system” of connected strings and made a “generator” powered by a rotting apple core… Our son is BACK!
Pittsburgh, Penn., May 2009

2. Health Care Costs

Health care costs were primarily for doctors visits, followed by lab fees; it was unclear why he was so sick and so extensive diagnosis and lab work was required (the repeated blood tests were NOT fun!). We got our final diagnosis at Children's Hospital in Boston (hence the travel costs).

Type of expense	**Total Cost**	**Out-of-pocket**
Doctor visits	$2,667	$2,200
Lab fees	$1,641	$1,359
Medication	$127	$127
Travel/lodging	$229	$229
Total	**$4,664**	**$3915**

These are the expenses for which we kept receipts (tailored for this presentation). If anything, this number is low.

Hidden costs

The financial costs shown above do not reflect a hidden cost: lost income. My husband significantly reduced his work to help care for our son. Because we had our own business in which my husband was paid per hour for his work, this was a real additional cost.

Insurance

When my son got sick we had a high-deductible health care plan; we had to pay $2,500 out of pocket each year before the insurance would start to pay. Our son's health care expenses started in November, so by the end of December we get to our annual deductible, only to start again in January. By the time we reached our deductible in the second year, our son was getting better. So our health insurance was almost useless! That was why although we technically "had health insurance" the out-of-pocket expenses were so high.

3. Detailed Remediation Costs from Randy Kritkausky

As written by Randy Krikausky

I located the reverse osmosis system that we use by searching the web for consumer reports on reverse osmosis systems and arsenic removal. Starting from zero and having no reference point required a significant investment of time and energy. It would be great if this were organized and presented in a brochure, or at least the questions that a homeowner should ask/search be organized.

There are many such systems varying over a wide range of prices. It appears from consumer reports that one of the most effective systems is also least costly to purchase initially and least costly to maintain. It is an under-sink GE system that produces 10 gallons per day. This is enough for drinking and cooking needs. (There is no evidence that bathing or washing in water moderately contaminated with arsenic is a problem. The cost of household systems is many thousands of dollars. We spent months investigating these household systems and having sales agents and consultants visit our house.)

We tested our water repeatedly, using the Vermont Health Department labs, before and after installing the reverse osmosis system. We also retested after 6 months of use and will continue to monitor. Arsenic and other minerals are now all below detectable limits

Since we have extremely hard water, it was necessary for us to also purchase and install a water softener. (Hard water destroys a reverse osmosis system.) This was more expensive than the reverse osmosis system. Here are the financial details:

1. Initial purchase cost of GE Reverse osmosis system $279 USD (plus tax).
2. Cost of installation by plumber was $175.
3. Cost of replacement sediment filters is $34.95 every six months. *
4. Our GE household water softener had an initial purchase price of $539 (plus tax).
5. Bags of salt are $6-8. **
6. Cost of installation by plumber $250. ***

   * The osmosis membrane lasts five years if the system is maintained-sediment pre-filters removed and system flushed. This can be done by the average home-owner and takes one hour.

** Three are needed to start, one needed about every two months.

*** I did some preliminary work myself. If the plumber did everything it might add another $200.

The cost of the testing and solution was a fraction of the cost of the health problems and diagnosis, and that does not put a price on the unnecessary suffering and anxiety that we needlessly experienced.

4. Details of State Research

Chosen States

States were chosen based upon four factors. The first group of states were those in the region that are expected to have similar bedrock to that found in Vermont and are therefore likely to have similar amounts of arsenic present in their groundwater. These states include those located in the northeast; New Hampshire, Maine, Massachusetts, Connecticut, Rhode Island, New York and New Jersey. The second set of states are those located in the southwest and the Rocky Mountain range, these areas have been found to have high levels of arsenic in their groundwater. These include, Arizona, Colorado, Montana, Nevada, New Mexico, Utah, Wyoming, and Idaho. California was included as an example of a state with a similar political atmosphere to that found in Vermont. The final state Wisconsin was chosen as a representative of a state with industries similar to those found in Vermont (i.e. dairy farming).

Connecticut

Public Health Code 19-13-B101 requires all newly drilled wells to be tested for contaminants. Before the water can be tested, the private water supply system must be disinfected (and all disinfectant must dissipate), and no other forms of water treatment (such as water softeners and reverse osmosis systems) should be implemented. Samples of well water must be collected by an individual qualified by either the state (such as licensed sanitarians and state and local health department employees) or by laboratories certified by the Department of Public Health. These samples are tested at certified laboratories for total coliform, nitrate, nitrite, sodium, chloride, iron, manganese, hardness, turbidity, pH, sulfates, and apparent color and odor. Further testing on organic chemicals must be conducted if there is reason to believe that they might be present in the well water. If nitrate levels are found to be at or above 10 milligrams per liter, the samples must be tested further for pesticides and herbicides such as alachlor, atrazine, dicamba, ethylene dibromide (EDB), metolachlor, simazine and 2, 4-D. The results of the test must meet the maximum contaminant levels (MCLs) set by the EPA before the well can be approved for use.

In addition, sellers of properties with private well water systems are required to disclose the condition of the well water to buyers at the point of sale. However, buyers are not required to investigate the condition of the well water themselves (although the state strongly recommends it), and test results cannot be a condition or consequence of sale, purchase, exchange, transfer, or rental of the property on which the private well water system is located (Connecticut Public Health Code 19-13-B101).

Missoula County, Montana

The Missoula County Water Quality District offers free arsenic test kits to anyone on a private well water system who wants them. This program began after sediment behind a mill dam classified as a Superfund site had accumulated high levels of arsenic; in addition, groundwater from parts of the county outside of the immediate vicinity of the Superfund site were shown to have levels of naturally-occurring arsenic that were higher than the maximum contaminant level (MCL) set by the EPA. The Missoula County government and the state health department began withholding permits for new subdivisions until the groundwater at those locations was tested for arsenic; the free test kit program was implemented not long after the permit policy began.

The free arsenic test kit program is funded by a $9.90 fee on annual tax bills which helps provide funding for Water Quality Districts for research, testing, and enforcement of policies relating to water quality. At the beginning of the program five years ago, approximately 50-60 free test kits were distributed per year, at a cost to the state of about $10-15 per test kit. However, currently only about 20 free kits are distributed by Missoula County per year; in 2010, only 6 free kits have been distributed so far ("Wells," Missoula Valley Water Quality District).

New Jersey

The New Jersey Department of Environmental Protection has a Private Well Testing Act (PWTA), which requires that when property with a private drinking water well is sold or leased, the well water must be tested for contaminants. Samples for testing must be collected by either an employee of a drinking water lab certified to collect PWTA samples or by an authorized representative of such a lab. The results of the water testing must be reviewed by both the buyer and seller. A closing of the title of sale may not occur unless both buyer and seller have signed a paper certifying that they have received and reviewed a copy of the water test results. When there is a sale of property, the costs are negotiated between buyer and seller. When property is leased, the landlord must obtain and pay for testing and provide results to the tenant(s).

Contaminants tested for depend on the county in which the private well is found. All wells are tested for total coliform bacteria, iron, manganese, pH, all volatile organic compounds (VOCs) with MCLs, nitrate, and lead. Certain counties have to test for arsenic, mercury, and 48-hour gross alpha particle activity. For example, naturally occurring arsenic is found mostly in the Piedmont Region.

If well water does not meet one or more of the drinking water standards, property sale can still be completed. This law mainly ensures that all parties in the real estate transfer know the facts about the well water so that they can make informed decisions. If well owners choose to treat the water, they are responsible for paying for treatment or obtaining assistance for payment. In some cases, the DEP or other government agencies may provide funding assistance for treatment. The Spill Compensation Fund Program is administered by the Environmental Claims Administration within the NJ Department of Environmental Protection, and it helps innocent parties suffering from direct or indirect damages resulting from human-caused discharge of a hazardous substance. The NJ Housing and Mortgage Finance Agency has a Potable Water Loan Program that is available to owners of single family residences whose source of potable water exceeds NJ Primary Drinking Water Standards ("Private Well Testing Act, Frequently Asked Questions," New Jersey Department of Environmental Protection).

New York

New York does not have any statewide regulations concerning the testing of private wells. However, several counties have their own regulations:

<u>Westchester</u>

The Westchester County Private Well Testing Legislation has Local Law 7, which applies to properties served by private wells used for drinking water, and requires that a water test be conducted upon the signing of a contract of sale for any property served by a private well. The law also requires such testing on a regular and ongoing basis for leased properties, and prior to the use of water from new wells or wells that have not been in use as a potable water supply for a period of five years. When there is a sale of property, the costs for testing for the parameters set forth in the law are borne by the seller. The law does not prohibit the sale of property if the water fails one or more primary parameter drinking water standards. When property is leased, the lessor must obtain and pay for the testing and provide the results to the tenant.

All water tests conducted pursuant to this Local Law require a test for at least the following parameters: bacteria (total coliform); either fecal coliform or Eschericia coli (E. coli) if the sample tests positive for total bacteria; chloride; nitrate, pH, arsenic; iron; manganese; sodium; lead; all primary organic contaminants (POCs) included in Part 5 of the New York State Sanitary Code; vinyl chloride; methyl-tertiary-butyl-ether (MTBE); and any additional parameters required by Westchester County Department of Health rule and regulation. Only certified laboratories are authorized to conduct the water tests and only employees or authorized representatives of the laboratory are authorized to collect the water sample(s). Estimated costs of testing are between $400-$450. The law sets forth procedural requirements placed on sellers, purchasers, lessors, and owners, as appropriate, to remediate or correct the condition of a primary parameter water test failure to establish safe levels of contaminants. However, no assistance is offered for installation and maintenance costs associated with water treatment. Finally, the law establishes civil penalties for non-compliance ("Private Well Water Testing," Westchestergov.com).

Rockland

Upon the signing of a contract of sale for any property served by a private water system within Rockland, the seller will be required to begin the process of testing the well water and to obtain written certification from a New York State approved laboratory that their private water system conforms to county water standards. Property sellers would be required to obtain a certified laboratory test of a wide range of contaminants, not just bacteria, and results are shared with both parties. The property seller will be required to arrange for and pay the cost of this testing and, within ten days of the contract provide the purchaser with confirmation that the test has been ordered. Within 60 days of ordering the test, the seller and buyer would certify that they have received and reviewed the water test results. County landlords have to test wells at least once every five years, alert residents of results, and remediate problems. New wells require testing and remediation if necessary before they can be put into use for the first time. Each water sample is analyzed for the following parameters: Total coliform bacteria; either fecal coliform or Escherichia coli (E. coli) if the sample tests positive for total coliform bacteria; chloride; nitrate; pH; arsenic; iron; manganese; sodium; all Principal Organic Contaminants (POCs) listed in NYSDOH Subpart 5-1, Table 9D; Methyl-tertiary-butyl-ether (MTBE); and vinyl chloride. Public notification shall be provided at the discretion of the RCDOH, with the decision based upon an assessment of the potential risk to public health. Factors considered in this assessment shall include but not be limited to: severity and type of contamination, proximity of known contamination to other dwellings or places of employment, proximity to public water supplies, knowledge or lack thereof of the contaminant source, status of any related remediation actions, migration potential of the identified contaminants, and status of prior notifications within the same area. Such notification may be in any form deemed suitable by the RCDOH. If the RCDOH provides public notification, such notification shall, at a minimum, be distributed to all property owners within two hundred (200) feet from each boundary of the subject property (Laws of Rockland County, New York, Section 389).

Dutchess County

The Comprehensive Well Water Testing Program tests private water wells at randomly selected single family, owner-occupied homes throughout the county. This program was designed to further community knowledge about the quality of groundwater well sources throughout the county. This testing for bacteria, inorganic chemicals, and organic chemicals comes at no direct personal cost to homeowners ("Comprehensive Well Water Testing Program," Dutchess County, New York).

Utah

The Utah Department of Agriculture and Foods runs the State Groundwater Program as implemented by the legislature in 1996 via the Utah Safe Drinking Water Act. It received funding to provide free testing for private wells from the legislature, but budget constraints have cut its funding as of 2009. The program's testing of pesticides is funded by the US EPA ("Have Your Well Water Tested for Free," Utah Department of Agriculture and Food).