LETTER HEALTH CONSULTATION

HOOKSETT RESIDENTIAL WELL WATER

HOOKSETT, NEW HAMPSHIRE

Prepared by New Hampshire Department of Environmental Services

March 23rd, 2021

Prepared under a Cooperative Agreement with the

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Agency for Toxic Substances and Disease Registry

Division of Community Health Investigations

Atlanta, Georgia 30333

APPLETREE

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

NH DIVISION OF Public Health Services Department of Health and Human Services

Agency for Toxic Substances and Disease Registry's Partnership to Promote Local Efforts to Reduce Environmental Exposures

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from the Agency for Toxic Substances and Disease Registry (ATSDR), or ATSDR's Cooperative Agreement Partners, to a specific request for information about health risks related to a specific site, a chemical release or the presence of hazardous materials. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies, intensifying environmental sampling, restricting site access, or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate health outcome data or trends in adverse health outcomes; measuring environmental chemicals in the human body to assess exposure (biomonitoring); and providing health education for health care providers and community members.

This recommendation of public health actions concludes the health consultation process for this site, unless additional information is obtained by ATSDR or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued. The Letter Health Consultation becomes the written report retained for records and is publicly accessible.

Members of the ATSDR Cooperative Agreement in the state of New Hampshire, including members of the New Hampshire Department of Environmental Services – Environmental Health Program (NHDES EHP) and the New Hampshire Department of Health and Human Services – Division of Public Health Services (NHDHHS DPHS), conducted the following health consultation. This Letter Health Consultation report contains analysis and recommendations specific to a site of interest in the state of New Hampshire. Therefore, ATSDR, its officers and subject matter experts contributed exclusively in a supporting role.

You May Contact NHDES
at (603) 271-3503

You May Contact NHDES EHP
at (603) 271-6803
or
Visit the NHDES website.

LETTER HEALTH CONSULTATION

HOOKSETT RESIDENTIAL WELL WATER ASSESSMENT

HOOKSETT, NEW HAMPSHIRE

STATE OF NEW HAMPSHIRE
Department of Environmental Services
Air Resources Division
Environmental Health Program
29 Hazen Drive, Concord, NH 03301

STATE OF NEW HAMPSHIRE

Department of Environmental Services
Environmental Health Program
Inter-Department Communication

To: Brandon Kernen, P.G., Drinking Water & Groundwater Bureau Administrator

Date: March 23rd, 2021

From: Robert Thistle Ph.D., Human Health Risk Assessor
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RE: Hooksett Residential Well Water Health Risk Assessment

STATE OF NEW HAMPSHIRE
Department of Environmental Services
Air Resources Division
Memorandum

Addressed:

March 23rd, 2021
To: Brandon Kernan, P.G., Administrator – Drinking Water and Groundwater Bureau, NHDES
From: Dr. Robert Thistle, Environmental Health Program
Re: Hooksett Residential Well Water Health Risk Assessment

Per your request, NHDES EHP has reviewed the analytical results of residential well water samples collected in 2019 and 2020 in the township of Hooksett, NH to (1) formally summarize the findings; (2) characterize potential exposures to these residential well users; and (3) recommend next steps to reduce exposure and protect public health for this community.

Review of the available residential well water sampling data indicates uranium and radon are the primary contaminants of concern in southern Hooksett. Of the wells tested, 64% exceeded acceptable health limits for uranium in drinking water as set by the Environmental Protection Agency. In addition, 90% of wells tested contain radon levels that may contribute to exceedance of recommended action levels in the air within homes. Finally, select residences have levels exceeding health standards for one or more additional contaminants such as arsenic (2%), manganese (23%), nitrates (2%), and per- and polyfluoroalkyl substances (PFAS) (22%).

A more detailed analysis of the results, including a summary of known human health risks associated with exposure and recommendations for exposure reduction, is outlined in the following document.

For questions regarding this consultation please contact:

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Background and Statement of Issues

In September of 2019, groundwater testing around the town of Hooksett, NH detected elevated levels of uranium, and the State responded to assess the risk and propose ways to protect the health of the public. This letter is a summary of our findings; it includes guidance to help the requester, as well as municipal officials and the public, understand risk to the community and what the recommended actions are to reduce risk.

The NHDES Drinking Water and Ground Water Bureau (DWGB) responded to this by partnering with the United States Environmental Protection Agency (EPA) to conduct additional sampling of residential wells in Southern Hooksett. NHDES developed a sampling plan in a targeted study area to test the drinking water quality for uranium and other potential groundwater contaminants. The aim of this sampling effort was to inform homeowners, and provide guidance regarding actions to reduce exposure and protect health. This study was made possible at no cost to the homeowners through the support of the EPA Region 1 Laboratory and the New Hampshire Drinking Water and Groundwater Trust Fund.

Water samples were collected from residences in southern Hooksett beginning in September 2019 and concluding in February 2020. Analysis of all contaminants in these samples was completed in October 2020, at which time DWGB requested support from EHP in order to evaluate potential health risks and to formulate recommendations based on findings. Staff support for this risk assessment activity was provided by ATSDR's Partnership to Promote Local Efforts to Reduce Environmental Exposure (APPLETREE) Cooperative Agreement.

The town of Hooksett is located in Merrimack County in south-central New Hampshire, with an estimated population of 14,569 (NH Department of Health and Human Services, 2019). Hooksett is situated on the Merrimack River between the city of Manchester to the south and the city of Concord to the north. According to 2010 US Census data, Hooksett contained 4,926 households, out of which ~34% housed children under the age of 18. Hooksett mirrors the state of New Hampshire in many demographics, including race, age distribution, healthy lifestyle habits and indices of cancer (NH Department of Health and Human Services, 2019).

New Hampshire has an abundance of groundwater, which many residents utilize for drinking, food preparation, recreation, irrigation and hygienic practices. More than 500,000 residents, nearly half (40-46%) of the state's population, source drinking water from residential wells (NH Department of Environmental Services, 2014). These wells are not regulated by the same standards for safe consumption and use as public water sources in the state of New Hampshire, and can be subject to certain naturally-occurring contaminants like arsenic, iron, manganese and uranium, in addition to human-caused contamination. While the majority of ground water is safe for consumption and use, NHDES urges well users to periodically monitor well water for contaminants that can impact their health.

Based on the preliminary detection of uranium in well water, residents with potentially contaminated water were identified in an area of Southern Hooksett. NHDES and EPA undertook a holistic screening approach for uranium and additional potential contaminants in the residential water sources within the surrounding area. This Letter Health Consultation addresses three key issues:

1. Identification of potential risks to human health from contaminated residential drinking water.
2. Recommended Actions for residents who are exposed to these potential risks.
3. Additional concerns for residents of Southern Hooksett and other stakeholders.

Current Sampling Event and Investigation

NHDES staff and partners sampled 138 residential wells located in an approximately 2.5 square-mile area of southern Hooksett, east of the Merrimack River and west of Tower Hill Pond (Appendix A, Figure 2). The samples were taken from pre- and post-treated sources, where available. Wells were selected based on a targeted area surrounding initial findings of elevated levels of uranium in groundwater. Initial screening revealed concentrations of uranium exceeding the EPA Maximum Contaminant Level (MCL) of 30 micrograms per liter (µg/L) in a small number of potable water sources.

Subsequent water analysis included, but was not limited to, the following analytes.

- Volatile organic compounds (VOCs)
- Trace metals/metalloids/Inorganics
- Per- and polyfluoroalkyl substances (PFAS).
- Radiological isotopes

Results are summarized by compound category in Appendix B, Tables 1-5. VOCs were measured using EPA Method 524.2 by ChemServe Environmental Analysts (Table 1). EPA partners provided metals analysis (Table 2). Samples were analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) as detailed in EPA Methods 200.2 and 200.8 for total recoverable metals. A small number of these samples were analyzed independently of EPA laboratories. As NHDES recently proposed ambient groundwater quality standards (AGQS) for certain PFAS, NHDES also analyzed 166 samples for 25 PFAS using Isotope Dilution, by Eurofins TestAmerica – Buffalo (Table 3). Radon in water was measured using Standard Method 7500 by Nelson Analytical Lab (Table 4).

Of the 124 analytes screened, 45 contaminants were within the range of detection in at least one or more residential wells. These concentrations were compared against ATSDR comparison values (CVs) to identify exposures of concern (Tables 1-5). When ATSDR CVs were not available, other guidance values from EPA or the State of New Hampshire were substituted in place. Due to the diversity of PFAS and their categorization as emerging contaminants, only those with ATSDR CVs or state-derived MCLs were further analyzed. For radiological compounds, EHP consulted with ATSDR subject matter experts (SMEs) for best available methods to characterize the radiological and chemical hazards of these substances.

Of these wells, 82 (64%) exceeded the regulatory MCL for use as a drinking water source due to the level of uranium. For radon, EPA has proposed a requirement for drinking water to contain less than 4,000 picocuries per liter (pCi/L) (this proposed MCL is non-regulatory and part of a multimedia mitigation program). In wells tested, 90% exceeded this value. For uranium and radon comparisons, sample data was also compared to available state data (Figure 1) (Flanagan, 2014); (Bartholomay, 2007). Concentrations and maps can be seen in Figures 2 and 3, Appendix A. Other contaminants of concern are listed in Table 5.

NHDES notified individual residents about their results with reports specific to their residence. Notifications included a complete list of analytes measured as well as instances of exceedance of federal and state guidelines for exposure. Notifications also included resources for more information, recommendations for actions to reduce risk by exposure, and pertinent contact information for NHDES employees. This Letter Health Consult expands on that summary.

Discussion

The key issues discussed here are:

1. Identification of potential human health risks.
2. Recommended Actions to reduce risks.
3. Additional concerns for residents and stakeholders.

Potential risks to human health

This health consultation evaluated exposure and risks from the use of residential wells as a source of drinking water. While exposure routes can include ingestion of drinking water, inhalation of gas and vapors, and dermal absorption; findings from testing associated with this health consultation primarily indicate ingestion as the exposure route of concern. The one exception to this is with radon. Resource limitations and lack of data to predict elevated levels of radon in drinking water prior to sampling impacted programmatic decisions to limit environmental testing to water; however, levels of radon in water are closely correlated with radon in air. Based on water results, we would predict the presence of radon in air.

It should be noted that health risks from exposure to radon by inhalation supersede those of ingestion. Therefore, this report assesses the potential impact on human health from consumption of contaminated drinking water with the understanding that inhalation should be considered as a follow up exposure route for future analysis. Other chemicals for which inhalation or dermal absorption can act as routes of exposure were either present at very low levels or not detectable (for instance, VOCs). Therefore, these routes of exposure were excluded from detailed analysis.

To evaluate potential risk, NHDES uses the dose of a given chemical to which a person is exposed from drinking water. The dose is estimated using a measured concentration from the drinking water source, a typical person's body weight, a duration of time, and other exposure factors (see Appendix C). The dose is then compared to ATSDR (CV) doses. When ATSDR lacks a CV for a given chemical, alternative guidance from either EPA (for example, a MCL) or the State's drinking water values is applied. If the dose exceeds the CV, then the analyte is further evaluated in a variety of exposure scenarios in order to inform the public if the risks require action, such as switching water sources to bottled water or installing appropriate filtration. If the dose is far below the CV or the analyte is not detected, the analyte is not retained for additional evaluation.

For the purpose of this report, contaminants of concern are defined as those contaminants that were found in one or more wells at levels likely to adversely impact human health. These levels are defined by exceedance of ATSDR, EPA or NHDES risk-based guidance values for drinking water. A complete list of contaminants tested for is included in Table 1-4; and those identified as contaminants of concern based on findings are included in table 5, and discussed in detail in this report. In addition to this report, individual well owners were provided with their specific results.

Uranium

Uranium is a radioactive, heavy metal that occurs naturally in nearly all rocks and soils. Some parts of the United States exhibit higher than average uranium levels due to natural geological formations, such as sedimentary rock and granite formations. These metal deposits have the potential to leach into groundwater. Over the long-term, consumption of water containing levels of uranium above the MCL is not advisable. Uranium that is absorbed is deposited throughout the body with the highest levels found in the bones, liver and kidneys (Agency for Toxic Substances and Disease Registry, 2013). Animal studies indicate that kidney damage is the primary toxic effect of uranium exposure and that this damage increases with uranium solubility and duration of exposure (Agency for Toxic Substances and Disease Registry, 2013).

ATSDR relies on the drinking water guidance value (for instance, MCL) developed by EPA, and does not have its own minimal risk level (MRL) or CV. Uranium was detected in most residential wells (more than 60%, Table 4) above the EPA MCL of 30 µg/L from untreated sample locations. Elevated uranium in drinking water is consistent with compositions predicted for the geological formations in southern Hooksett (Lyons, 1997). For wells with a uranium level at or above 30 µg/L, treatment to remove uranium should be installed or an alternate source of drinking water such as bottled water should be utilized. As levels of contaminants may change over time, retesting is recommended at least every 3-5 years for wells with a uranium level under 30 µg/L (New Hampshire Department of Health and Human Services, 2019).

Radon

Radon is a noble gas byproduct from the radioactive decay of crustal elements like uranium and radium. Radon is released into soil pockets where it can diffuse into surrounding air, water and soil. Radon gas emits energetic alpha particles during decay. Almost all health risks from radon in water come from breathing indoor air with radon (which accumulates depending on factors like ventilation, seasonal change, and aerosolization of dissolved radon) and exposure to radon gas is the second leading cause of lung cancer in the United States, after smoking. More than 15,000 – 21,000 deaths are attributed annually to radon-related lung cancer (National Research Council, 1999). This risk is increased for people who are also exposed to cigarette smoke (RW, 2001). Based on data from the New Hampshire State Cancer Registry and Center for Disease Control (CDC) estimates about the proportion of lung cancer deaths attributable to radon at the national level, it's estimated that approximately 100 lung cancer deaths each year in New Hampshire are attributable to radon. This estimate does not take into account additional risk factors, including the age of the New Hampshire population, lung cancer screening rates and the distribution of stage at diagnosis, and, perhaps most importantly, smoking rates for the state.

Enforceable federal or state standards for radon present in drinking water or indoor air do not currently exist. However, EPA and other agencies do issue public health advisories for radon in drinking water (US Environmental Protection Agency, 1999) and indoor air (US Environmental Protection Agency, 2016). The majority (69%) of sampling results for radon in water samples collected in the study area show radon in water levels exceeding 10,000 pCi/L. As a general practice, NHDES strongly recommends that private wells with radon concentrations at or above 10,000 pCi/L install treatment for the water in conjunction with mitigation of indoor air radon. For private wells with radon concentrations between 2,000 and 10,000 pCi/L, the treatment of water may be advisable if air concentrations in the home exceed 4 pCi/L (US Environmental Protection Agency, 2016)

Arsenic

Arsenic is a naturally occurring element in minerals of Earth's crust as well as a byproduct of the smelting process of certain metals like copper and lead. Inorganic arsenic is a well-documented toxic agent, causing hyperkeratinization (abnormally rapid shedding of skin cells) and hyperpigmentation of skin (darkening of patches of the skin). Cardiovascular, pulmonary and neurological functions are also impaired by arsenic exposure through consumption, with acute, high-level exposures causing encephaly. Following chronic exposure, pregnant women are at higher risk for pregnancy complications and children are at higher risk for neurodevelopmental effects (Gilbert-Diamond, 2016; Farazan, 2016); (Farazan, 2016). Arsenic is also a known carcinogen implicated in increased tumor incidence in many organs, including the bladder, lung and skin (non-melanoma), following chronic exposure (Agency for Toxic Substances and Disease Registry, 2007).

Arsenic was detected above the ATSDR CV of 16 µg/L (from the untreated sample location) at three residences. At 3% of wells, concentrations exceeded the proposed New Hampshire health limit for arsenic of 5 µg/L, which will be lowered from 10 µg/L in July 2021 to protect neurodevelopment and IQ scores for infants and small children. The new value is also being lowered to protect against the carcinogenic effects of long-term exposure (Borsuk, 2015) (NH Department of Environmental Services, 2020).

Manganese

Manganese is a natural element found in soil and groundwater within New Hampshire, and is also an essential nutrient in our diet. Excessive exposure to manganese is associated with neurological effects, including neuro-degenerative symptoms like Parkinson's, altered emotional states and neurodevelopmental delays in children. This can be especially problematic for formula-fed infants, as their body processes (or metabolizes) manganese differently than older children and adults.

ATSDR does not suggest values for exposure limits to manganese in drinking water, but does recognize the potential for human health risk as determined by EPA. Manganese was detected at select residences above the EPA lifetime health advisory value of 0.300 milligrams per liter (mg/L) from the untreated sample locations. Over the long-term, consumption of water containing levels of manganese above this level is not advisable.

PFAS

Per- and polyfluoroalkyl substances (PFAS) are a group of man-made organic chemicals used in a variety of industrial and commercial applications. Certain PFAS are highly-bioaccumulative and associated with a variety of adverse health outcomes, including increased cholesterol, changes in liver enzyme levels. altered hormone function, delayed growth in infants and potentially certain cancers (Sunderland, 2019).The ATSDR CVs for these determined little to no intermediate exposure risks (less than 1 year) for four PFAS.

In 2019, NHDES adopted rules that establish health-based MCLs and AGQS for four PFAS that include: 12 parts per trillion (ppt) for perfluorooctanoic acid (PFOA), 15 ppt for perfluorooctane sulfonic acid (PFOS), 18 ppt for perfluorohexane sulfonic acid (PFHxS), and 11 ppt for perfluorononanoic acid (PFNA). These values were based on chronic protection of women who are planning on becoming pregnant or breastfeeding, and are therefore lower than the ATSDR CVs (NH Department of Environmental Services, 2019). Approximately 21% of residential wells exceeded the AGQS for PFOA, while 4%, 3%, and < 1% of residential wells exceeded the AGQS for PFNA, PFOS, and PFHxS, respectively.

Recommended Actions for Homeowners

Based on the available information, there are three key recommended actions for homeowners and community members in the Southern Hooksett area.

1. **Encourage supplemental testing of wells**. Unfortunately, NHDES was not able to conduct an exhaustive survey of all possible drinking water contaminants for all residential wells, so additional testing is advisable before determining any treatment system options for a home. Some treatment system options are not designed to remove all types of contaminants, whereas others may be more economically feasible and still sufficient. NHDES recommends routine well testing every 3-5 years (except for bacteria and nitrates, which should checked annually) (NH Department of Environmental Services, 2020). NHDES can be contacted for discussion of test results. At the end of this document are

links to resources with additional information regarding contaminants in drinking water and treatment options.

2. **Conduct home air testing for radon gas.** Given the elevated levels of uranium and radon in drinking water for homes in the area, there is an increased probability that the indoor air of homes in the area will contain elevated levels of radon. Radon in the air of homes may come from radon in the water or radon gas infiltrating the home from the ground, or some combination of the two. DPHS recommends taking remedial action when air testing results are above the EPA Action Level of 4 pCi/L (NH Division of Public Health Services, 2011). More information can be found at the NHDHHS Radon Program and NHDHHS Radon in Air Reduction websites, including where in the home to test and during which time of year
   At the end of this document are links to resources with additional information regarding contaminants in drinking water as well as testing, treatment and mitigation options.

3. **Install filtration/treatment on untreated wells**. NHDES strongly recommends treatment of residential well water when contaminant levels are elevated and exceedances of health guidelines are observed. This is especially true for those with exceedances of uranium and radon, as the concentrations of these were far above the guidance for chronic exposures. At the end of this document are links to resources with additional information regarding contaminants in drinking water and treatment options.

For residents pursuing additional testing, the date of this letter health consultation may serve as a starting date for planning a 3-5 year follow up test. An accompanying fact sheet has been created for residents to summarize the recommended actions. New Hampshire APPLETREE will make this available and will also contact residents with future opportunities to engage with APPLETREE members regarding environmental health results and any remaining concerns.

Recommended Actions for Government Agencies and Research Institutions

It is possible that residential well sampling in this report is incomplete due to limitations in program funding and staffing. Pending the availability of resources, additional testing could be conducted to determine the full extent of geographic exposure. In addition, the community could be considered for health-related or biomonitoring studies to better assess and understand potential impacts of exposure. These studies would require additional resources at the state or federal level and involvement of other stakeholders such as academic institutions or universities.

Additional Concerns

The elevated presence of both uranium and radon present a radiological health hazard for residents. The basic philosophy of radiation protection at ATSDR is the concept of ALARA (as low as reasonably achievable) outlined by EPA (US Environmental Protection Agency, 1988). As a guidance, all exposure should be kept as low as reasonably achievable and the regulations and guidelines are meant to give an upper limit to exposure.

Figure 1: Percentage of Residential Wells Exceeding Guidance values for Uranium and Radon

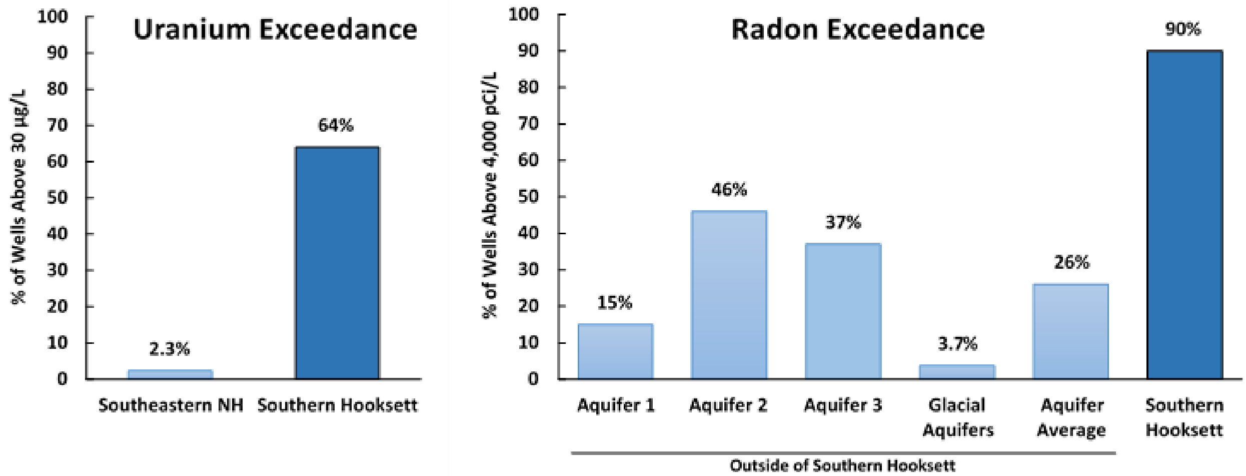

Figure 1: Levels of Uranium and Radon exceed human health guidance values with higher frequency in residential wells of Southern Hooksett compared to other regions in New Hampshire. Samples measured by United States Geological Survey (USGS) in Hillsborough, Rockingham and Strafford counties (this data set does not include Hooksett) showed only 2.3% of 232 wells had Uranium exceeding the EPA MCL of 30 µg/L compared to 64% of wells analyzed from Hooksett (Flanagan, 2014). A 2007 USGS report also measured samples from four aquifer cohorts in New Hampshire, demonstrating that 26% of 108 wells (Aquifer Average) contained radon exceeding the "US EPA human-health benchmark" of 4,000 pCi/L compared to 90% of wells analyzed from Hooksett (Bartholomay, 2007).

Public Health Implications

Some contaminants detected in Hooksett residential wells pose potential risks to human health. However, these risks can be reduced by homeowners. In addition, it may take a lifetime of exposure (over xx years) in order to increase the risk significantly for some contaminants. It is important to note that increased risk does not mean that a negative health outcome will definitely occur. Instead, an increased risk translates to an increased chance or likelihood of a negative health outcome occurring.

Testing of residential wells in Southern Hooksett suggests that the most common contaminants to drinking water in the area of study are uranium and radon. Many wells also have high levels of arsenic, manganese and PFAS. The majority of these contaminants have the potential to adversely impact human health following chronic exposure, meaning when exposure concentrations are elevated over a number of years. However, for certain contaminants, evidence indicates that even short-term exposure can impact health negatively for special populations like infants and pregnant women. Human health implications, treatment options and additional resources are provided below.

Contaminants present in private wells found in the Hooksett community are associated with increased risk for health conditions following chronic exposure, including:

- Certain cancers, associated with exposure to arsenic and radiological contaminants (radon and uranium).
- Kidney damage, associated with chronic exposure to uranium.

- Neurological effects in infants and young children, associated with chronic exposure to manganese.
- Increased cholesterol, changes in liver enzyme levels, altered hormone function, delayed growth in infants and potentially certain cancers, associated with chronic exposure to certain PFAS.
- Impact to fetal growth and increased infections in first year of life, associated with acute exposure to arsenic during pregnancy.

Understanding risks associated with environmental exposures can help to guide changes to reduce risk and to promote health. Similarly, there are a number of additional modifiable risk factors associated broadly with chronic disease; recommendations to reduce the overall health risk burden include eating a healthy and varied diet, avoiding smoking and other tobacco products, limiting consumption of sugar and sugary beverages, limiting alcohol consumption, incorporating physical activity into daily life, and getting adequate sleep. These actions, combined with appropriate water treatment, will reduce long-term health risk for residents of New Hampshire. It is also recommended that health risks and any specific health concerns be discussed between patients and medical care providers. This helps strengthen and optimize specific patient care.

Conclusions

Although some contaminants detected in Hooksett residential wells pose potential risks to human health, homeowners can take steps to reduce these risks. Learning about a new health risk can be worrisome for many people, yet there are simple and effective actions residents can take to test and then reduce the contaminants in their drinking water.

At the end of this document are links to resources with additional information regarding contaminants in drinking water and treatment options. NHDES strongly recommends treatment of residential well water when contaminant levels are elevated and exceedances of health guidelines are observed. Unfortunately, NHDES was not able to conduct an exhaustive survey of all possible drinking water contaminants, so additional testing is advisable before determining any treatment system options for a home. Some treatment system options are not designed to remove all types of contaminants, whereas others may be more economically feasible and still sufficient.

For more information on how to test well water and a guide for home buyers:

NHDES Residential Wells webpage.

NHDHHS Water Testing Guide

The most effective and inexpensive method homeowners can take to remove a large spectrum of contaminants in their drinking water is to install a point-of-use reverse osmosis (RO) treatment system. These systems typically are installed under a kitchen sink or in a basement, and provide water to a dedicated tap at the kitchen sink and potentially a refrigerator water/ice dispenser. Depending on the type of treatment system and who completes the installation, installing a reverse osmosis system will cost approximately $200-$1500. Please note that local plumbing codes may require a permit when installing water treatment systems.

For questions regarding well water test results and treatment options contact NHDES Water Analysis Laboratory:

NHDES Residential Wells webpage

Public Health Laboratory
New Hampshire Department of Health and Human Services
(603) 271-3445

For questions regarding this document or concerns about environmental impact on human health, contact the NHDES Environmental Health Program:

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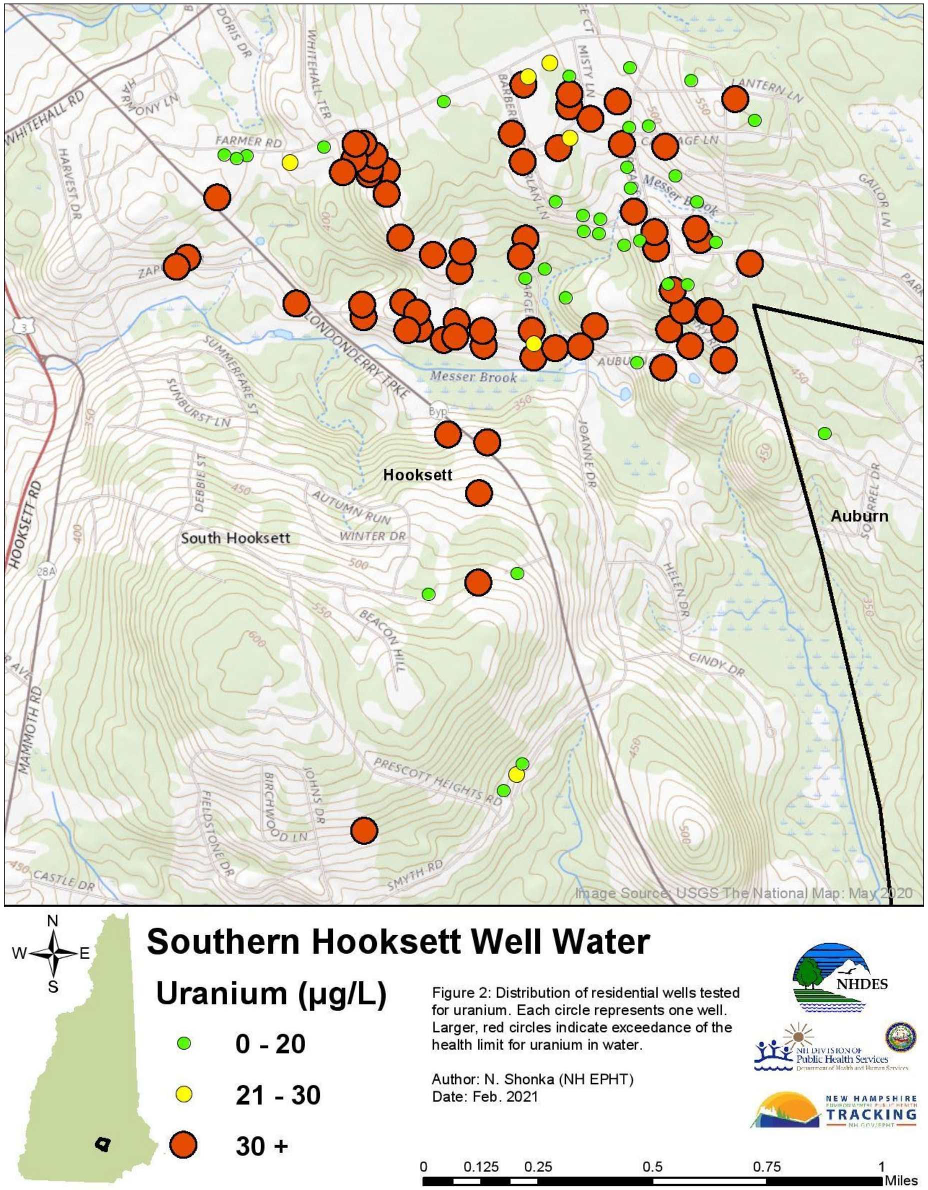
Appendix A: Figures

Figure 2: Map of Residential Wells Tested for Uranium in Hooksett with Concentration Range



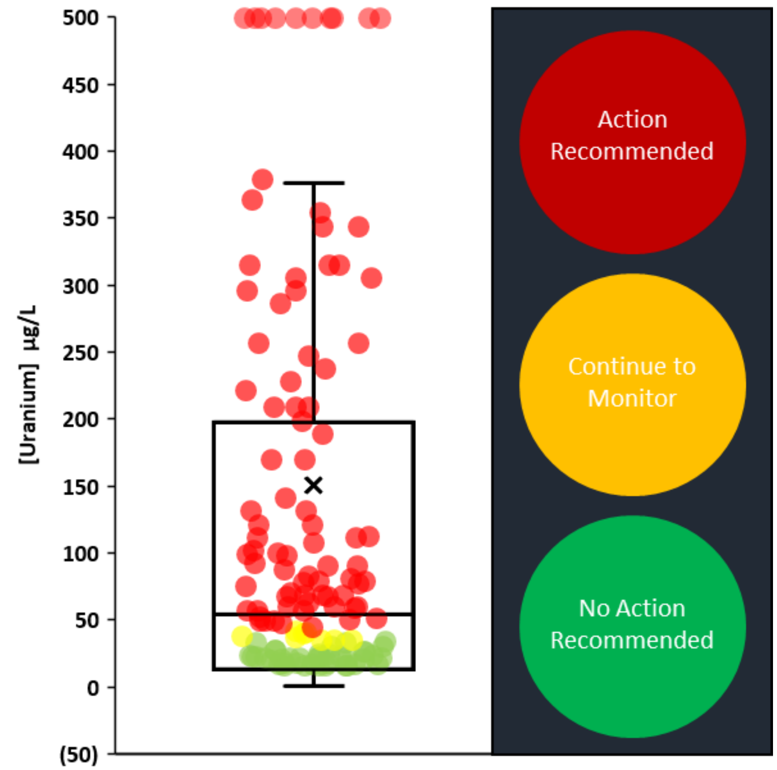
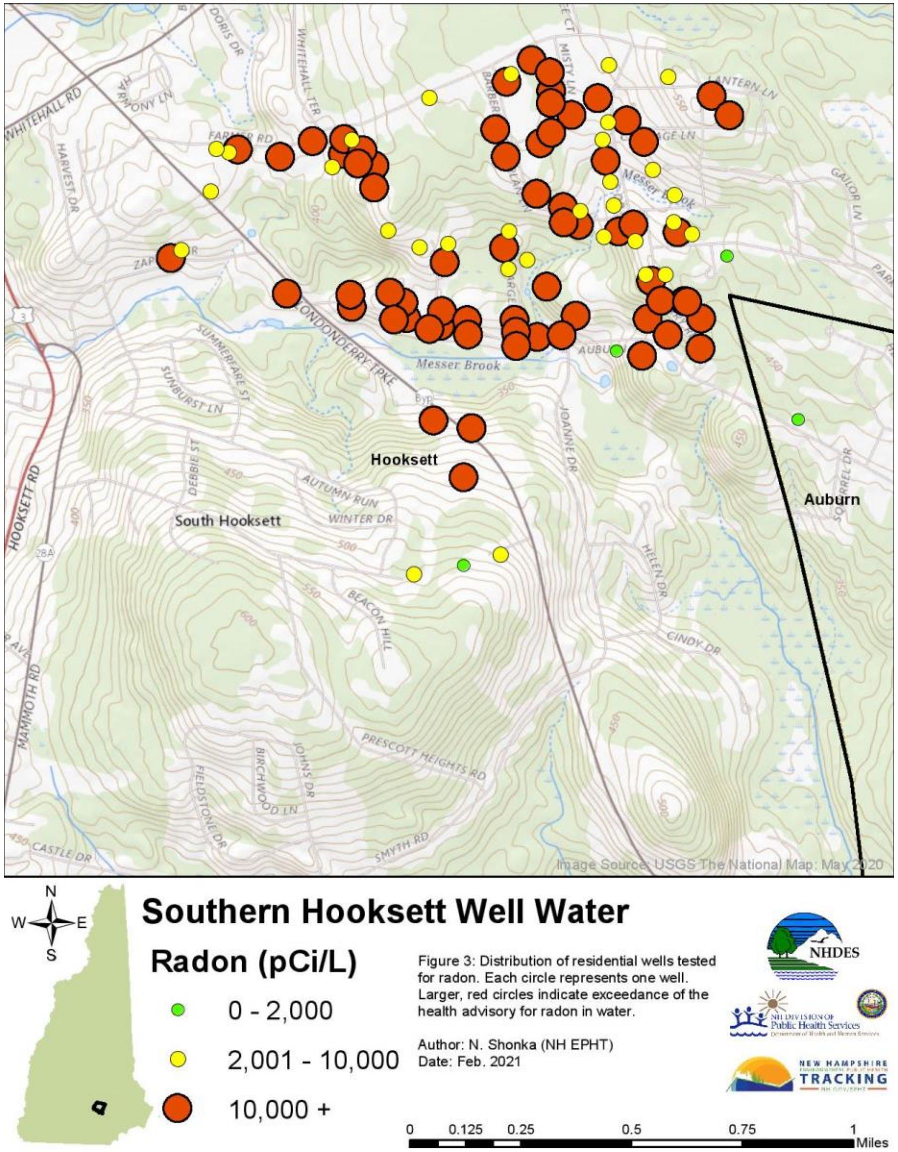
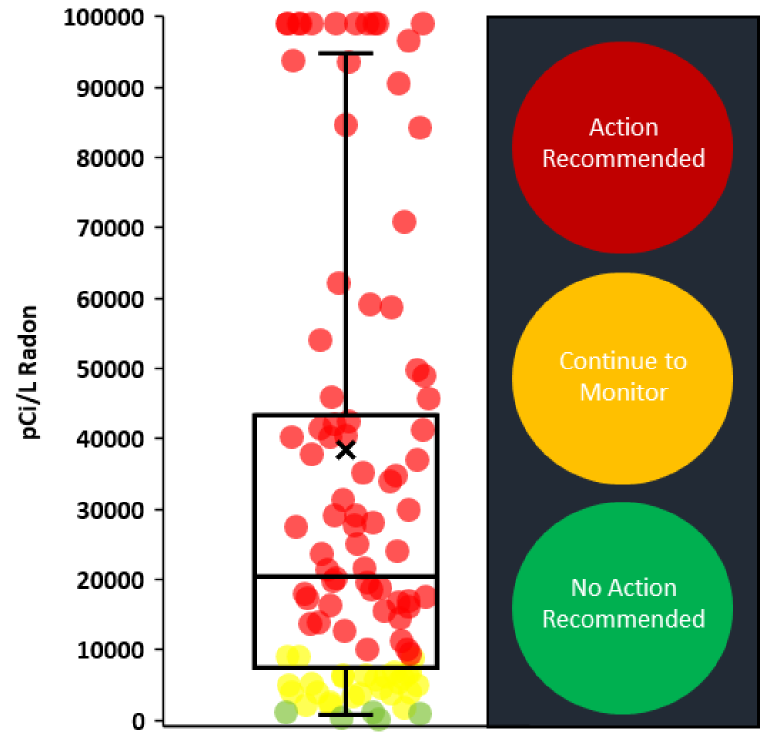


Figure 3: Map of Residential Wells Tested for Radon in Hooksett with Concentration Range





Appendix B: Tables

Notes for all Tables:

Keys for All Output Tables – For more calculations and further details see Appendix C

BW	Body Weight; weight in kilograms
CR	Cancer Risk; CR > 10-6 indicates increased risk
CREG	Cancer Risk Evaluation Guide; basis for how cancer risk is evaluated
CSF	Cancer Slope Factor; a cancer specific scenario exposure factor for a contaminant
CTE	Central Tendency Exposure; the central point used from a ranged exposure data set
CV	Comparison Value; an ATSDR standard dose or concentration for a contaminant
ED	Exposure Duration; the amount of time exposed to a contaminant
EF	Exposure Factor; a corrective factor applied to evaluation to certain contaminants
EPC	Exposure Point Concentration; the concentration that is measured at a site
HQ	Hazard quotient; a fraction to determine if appreciable risk is present or not; HQ > 1 indicates increased risk
MCL	Maximum Contaminant Level; a US EPA standard concentration for a contaminant
MRL	Minimal Risk Level; an ATSDR dose at which no appreciable, non-cancer risk is expected
NC	Not Calculated
ND	Not Detected
RME	Reasonable Maximum Exposure; The maximum point used from a ranged exposure data set
RMEG	Reference dose Media Evaluation Guide; basis for how non-cancer risk is evaluated

§ Cancer risk (CR) is derived for both CTE (12 years) and RME (33 years) residential occupancy periods. For children, CRs are derived for a combined child receptor: CTE (12 years) and RME (21 years) at a given residence. For the CTE child CR, the combined child is the sum of the cancer risks for each age group for the first 12 years of exposure only. The RME CR for the combined child is derived by summing all the cancer risks for each age group from birth to < 21 years. The adult CR assumes living at the residence for 12 (CTE) or 33 (RME) years. Cancer risks can be calculated for contaminants with cancer slope factors stored in PHAST.

† Hazard Quotients are greater than 1. The health assessor should conduct further toxicological evaluation.

‡ Cancer risk is greater than $1.0E^{-6}$. The health assessor should conduct further toxicological evaluation.

Ω Cancer risks are not calculated for pregnant women and lactating women. Their cancer risks are similar to an adult woman exposed for 33 years. If you would like to calculate cancer risks for pregnant women and lactating women, enter site-specific scenarios.

1 Carcinogen; No cancer slope factor (CSF); See CVs and Health Guidelines Module for additional cancer class information.

3 Carcinogenicity not determined; Cancer risk was not calculated.

Table 1: Panel of Volatile/Semi-Volatile Organic Compounds Screened in Hooksett Residential Wells

Analyte	CAS No.	Detected	ATSDR CV (µg/L)	Other Guidance Value (µg/L)	% Above Guidance Value
1,1,1,2-Tetrachloroethane	630-20-6	ND	0.93	70	0
1,1,1-Trichloroethane	71-55-6	ND	14,000	200	0
1,1,2,2-Tetrachloroethane	79-34-5	ND	0.12	2	0
1,1,2-Trichloroethane	79-00-5	ND	0.43	5	0
1,1-Dichloroethane	75-34-3	ND	NA	81	0
1,1-Dichloroethene	75-35-4	ND	350	7	0
1,1-Dichloropropene	563-58-6	ND	NA	NA	0
1,2,3-Trichloropropane (TCP)	96-18-4	ND	0.4	NA	0
1,2,3-Trichlorobenzene	87-61-6	ND	NA	7	0
1,2,4-Trichlorobenzene	120-82-1	ND	70	70	0
1,2,4-Trimethylbenzene	95-63-6	ND	70	330	0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	ND	14	0.2	0
1,2-Dibromoethane (EDB)	106-93-4	ND	0.012	0.05	0
1,2-Dichlorobenzene	95-50-1	ND	630	600	0
1,2-Dichloroethane	107-06-2	ND	0.27	5	0
1,2-Dichloropropane	78-87-5	ND	490	5	0
1,3,5-Trichlorobenzene	108-70-3	ND	40	40	0
1,3,5-Trimethylbenzene	108-67-8	ND	70	330	0
1,3-Dichlorobenzene	541-73-1	ND	140	600	0
1,3-Dichloropropane	142-28-9	ND	NA	3,700	0
1,4-Dichlorobenzene	106-46-7	ND	490	75	0
2,2-Dichloropropane	594-20-7	ND	NA	NA	0
2-Butanone (MEK)	78-93-3	ND	4,200	4000	0
2-Chlorotoluene	95-49-8	ND	140	100	0
2-Hexanone	591-78-6	ND	35	38	0
4-Chlorotoluene	106-43-4	ND	100	100	0
4-Methyl-2-pentanone (MIBK)	108-10-1	ND	NA	2000	0
Acetone	67-64-1	ND	6,300	6000	0
Benzene	71-43-2	ND	0.44	5	0
Bromobenzene	108-86-1	ND	56	60	0
Bromochloromethane	74-97-5	ND	90	90	0
Bromodichloromethane	75-27-4	ND	0.39	80	0
Bromoform	75-25-2	**Y**	3.1	80	0
Bromomethane	74-83-9	ND	9.8	10	0
Carbon Disulfide	75-15-0	ND	700	70	0
Carbon Tetrachloride	56-23-5	ND	0.35	5	0
Chlorobenzene	108-90-7	ND	140	100	0
Chloroethane	75-00-3	ND	NA	2100	0

Chloroform	67-66-3	**Y**	70	80	0
Chloromethane	74-87-3	ND	NA	30	0
cis-1,2-Dichloroethene	156-59-2	ND	14	70	0
cis-1,3-Dichloropropene	10061-01-5	ND	NA	NA	0
Dibromochloromethane	124-48-1	ND	0.29	80	0
Dibromomethane	74-95-3	ND	NA	NA	0
Dichlorodifluoromethane	75-71-8	ND	1,400	1000	0
Diethylether	60-29-7	ND	1,400	1400	0
DIPE-diisopropyl ether	108-20-3	ND	NA	120	0
ETBE-ethyl-t-butyl ether	637-92-3	ND	NA	40	0
Ethylbenzene	100-41-4	ND	700	700	0
Hexachlorobutadiene	87-68-3	ND	0.31	0.5	0
Isopropylbenzene (Cumene)	98-82-8	ND	700	800	0
Methylene Chloride	75-09-2	ND	6.1	5	0
Methyl-t-butyl ether (MTBE)	1634-04-4	**Y**	2,100	13	0
Naphthalene	91-20-3	ND	140	100	0
n-Butylbenzene	104-51-8	ND	NA	260	0
n-Propylbenzene	103-65-1	ND	NA	260	0
p-Isopropyltoluene	99-87-6	ND	NA	260	0
sec-Butylbenzene	135-98-8	ND	NA	130	0
Styrene	100-42-5	ND	1,400	100	0
t-butanol	75-65-0	ND	NA	40	0
t-Butylbenzene	98-06-6	ND	NA	260	0
tert-Amyl methyl ether (TAME)	994-05-8	ND	NA	140	0
Tetrachloroethene	127-18-4	ND	12	5	0
Tetrahydrofuran (THF)	109-99-9	ND	6,300	600	0
Toluene	108-88-3	**Y**	560	1000	0
trans-1,2-Dichloroethene	156-60-5	ND	140	100	0
trans-1,3-Dichloropropene	10061-02-6	ND	NA	NA	0
Trichloroethene	79-01-6	ND	0.43	5	0
Trichlorofluoromethane	75-69-4	ND	2,100	2000	0
Vinyl Chloride	75-01-4	ND	0.017	2	0
Xylenes	1330-20-7	ND	1400	NA	0

Note: No mean concentrations of VOCs exceed ATSDR CVs or Other Guidance Values.

Y: Yes, detected, indicated with bold, yellow

ND: Not Detected

Table 2: Panel of Trace Metals, Metalloids, and Inorganic Molecules Screened in Hooksett Residential Wells

Analyte	CAS No.	Detected	ATSDR CV (mg/L)	Other Guidance Value (mg/L)	% Above Guidance Value
Aluminum	7429-90-5	**Y**	7	NA	0
Antimony	7440-36-0	ND	0.0028	0.006	0
Arsenic	7440-38-2	**Y**	0.016	0.005	**3.0%**
Barium	7440-39-3	**Y**	1.4	2	0
Beryllium	7440-41-7	**Y**	14	4	0
Cadmium	7440-43-9	**Y**	0.7	5	0
Calcium	7440-70-2	**Y**	NA	NA	NA
Chloride	16887-00-6	**Y**	NA	NA	NA
Chromium (hexavalent)	7440-47-3	**Y**	0.024	0.1	0
Cobalt	7440-48-4	**Y**	0.07	0.07	0
Copper (flushed)	7440-50-8	**Y**	0.07	1.3	**0.78%**
Fluoride	16984-48-8	**Y**	NA	4	0
Iron	7439-89-6	**Y**	NA	NA	NA
Lead (flushed)	7439-92-1	**Y**	0.015	0.015	**3.1%**
Magnesium	7439-95-4	**Y**	NA	NA	NA
Manganese	7439-96-5	**Y**	0.3	0.84	**5.4%**
Molybdenum	7439-98-7	**Y**	0.035	NA	**0.78%**
Nickel	7440-02-0	**Y**	NA	NA	NA
Nitrogen (Ammonia)	7664-41-7	ND	NA	NA	NA
Nitrate	14797-55-8	**Y**	11	10	**7.3%**
Nitrite	14797-65-0	**Y**	0.7	1	0
Selenium	7782-49-2	ND	0.035	0.05	NA
Silver	14701-21-4	ND	0.035	NA	NA
Sodium	7440-23-5	**Y**	NA	20	**67.%**
Thallium	7440-28-0	ND	NA	2	NA
Uranium	7440-61-1	**Y**	NA	30 (µg/L)	**64%**
Vanadium	7440-62-2	**Y**	0.07	NA	0
Zinc	7440-66-6	**Y**	2.1	NA	0

Note: Bold contaminants indicate exceedance of an ATSDR CV or Other Guidance Value
Y: Yes, detected, indicated with bold, yellow
ND: Not Detected

Table 3: Panel of PFAS Screened in Hooksett Residential Wells

Analyte	CAS No.	Detected	ATSDR CV (µg/L)	Other Guidance Value (µg/L)	% Above Guidance Value
6:2 fluorotelomer sulfonic acid - 6:2 FTSA	27619-97-2	**Y**	NA	NA	0
8:2 fluorotelomer sulfonic acid - 8:2 FTSA	39108-34-4	ND	NA	NA	0
n-ethyl perfluorooctane sulfonamido acetic acid - NETFOSAA	2991-50-6	ND	NA	NA	0
n-methyl perfluorooctane sulfonamido acetic acid - NMEFOSAA	2355-31-9	ND	NA	NA	0
perfluorobutane sulfonic acid - PFBS	375-73-5	**Y**	NA	NA	0
perfluorobutanoic acid - PFBA	375-22-4	**Y**	NA	NA	0
perfluorodecane sulfonic acid - PFDS	335-77-3	**Y**	NA	NA	0
perfluorodecanoic acid - PFDA	335-76-2	**Y**	NA	NA	0
perfluorododecanoic acid - PFDOA	307-55-1	**Y**	NA	NA	0
perfluoroheptanoic acid - PFHPA	375-85-9	**Y**	NA	NA	0
perfluorohexadecanoic acid - PFHXDA	67905-19-5	ND	NA	NA	0
perfluorohexane sulfonic acid - PFHXS	355-46-4	**Y**	140	18	**0.60%**
perfluorohexanoic acid - PFHXA	307-24-4	**Y**	NA	NA	NA
perfluorononanoic acid - PFNA	375-95-1	**Y**	21	11	**4.2%**
perfluorooctane sulfonic acid - PFOS	1763-23-1	**Y**	14	15	**3.0%**
perfluorooctanesulfonamide - PFOSA	754-91-6	ND	NA	NA	0
perfluorooctanoic acid - PFOA	335-67-1	**Y**	21	12	**22%**
perfluoropentanoic acid - PFPEA	2706-90-3	**Y**	NA	NA	0
perfluorotetradecanoic acid - PFTEA	376-06-7	**Y**	NA	NA	0
perfluorotridecanoic acid - PFTRA	72629-94-8	**Y**	NA	NA	0
perfluoroundecanoic acid - PFUNA	2058-94-8	**Y**	NA	NA	0

Note: Bold contaminants indicate exceedance of an ATSDR CV or Other Guidance Value (Other Guidance Values are from New Hampshire Ambient Groundwater Quality Standards)

Y: Yes, detected, indicated with bold, yellow

ND: Not Detected

Table 4: Radiological Isotopes Screened in Hooksett Residential Wells

Analyte	CAS No.	Detected	ATSDR CV (µg/L)	Other Guidance Value (µg/L)	% Above Guidance Value
Uranium	7440-61-1	**Y**	NA	30	**64%**
Radon 222	10043-92-2	**Y**	NA	4,000 (PiC/L)	**90%**

Note: Bold contaminants indicate exceedance of an ATSDR CV or Other Guidance Value; Radon measured in pCi/L.

Y: Yes, detected, indicated with bold, yellow

ND: Not Detected

Table 5: Summary of Contaminants of Concern Exceeding Guidance Values

Analyte	Category	ATSDR CV (mg/L)	Other Guidance Value (mg/L)	% Above CV	[Mean] (mg/L)	[Maximum] (mg/L)	[95%] (mg/L)
Arsenic	Metal/ Metalloid	0.016	0.005*	**3%**	0.0025	0.18	0.004
Lead (flushed)	Metal/ Metalloid	0.015	0.015*	**3.1%**	0.0017	0.024	0.00748
Manganese	Metal/ Metalloid	NA	0.300*	**16%**	0.27	8.2	0.92
Molybdenum	Metal/ Metalloid	0.035	NA	**0.78%**	0.0057	0.17	0.0154
Nitrate	Inorganic	10	NA	**7.3%**	2.2	13.4	10.4
PFHXS	PFAS	140 (µg/L)	18* (µg/L)	**0.60%**	2.3 (µg/L)	18 (µg/L)	8.475 (µg/L)
PFNA	PFAS	21 (µg/L)	11* (µg/L)	**4.2%**	1.7 (µg/L)	58 (µg/L)	4.55 (µg/L)
PFOA	PFAS	21 (µg/L)	12* (µg/L)	**22%**	35 (µg/L)	67 (µg/L)	16 (µg/L)
PFOS	PFAS	15 (µg/L)	14* (µg/L)	**3.0%**	7.6 (µg/L)	65 (µg/L)	9.975 (µg/L)
Radon (Radon 222)	Radiological/ Metalloid	NA	4,000 (PiC/L)**	**90%**	38000 (PiC/L)	286000 (PiC/L)	119900 (PiC/L)
Sodium	Metal	NA	20*	**67%**	37 (µg/L)	140 (µg/L)	96.55 (µg/L)
Uranium	Radiological/ Metalloid	30 (µg/L)	30 (µg/L)**	**64%**	150 (µg/L)	1900 (µg/L)	631.5 (µg/L)

Note: CVs and Other Guidance Values measured in mg/L unless otherwise noted. Radon measured in (PiC/L). Bold, yellow indicates exceedance of an ATSDR CV or Other Guidance Value

***Guidance Values from the State of New Hampshire and State of New Hampshire Biomonitoring**

****From EPA Maximum Contaminant Levels (MCLs) and/or recommendation**

Table 6: Uranium Exposure Risk Summary

Exposure Group	Site-Specific Scenario *Uranium (EPC: 0.631 mg/L; Intermediate MRL: 0.0002 mg/kg/day; CSF: NA Using Intermediate MRL)*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	0.041	0.090	**35** [α]	**450** [α]	*NC* [Ω]	*NC* [Ω]	1
1 to < 2 years	0.017	0.049	**85** [α]	**250** [α]			1
2 to < 6 years	0.014	0.035	**68** [α]	**180** [α]			4
6 to < 11 years	0.010	0.028	**51** [α]	**140** [α]			5
11 to < 16 years	0.0071	0.022	**35** [α]	**110** [α]			5
16 to < 21 years	0.0068	0.022	**34** [α]	**110** [α]			5
Total exposure duration for child cancer risk							21
Adult	0.0097	0.024	**48** [α]	**120** [α]	*NC* [Ω]	*NC* [Ω]	78
Pregnant Women	0.0075	0.022	**38** [α]	**110** [α]	*NC* [Ω]		
Lactating Women	0.014	0.031	**72** [α]	**160** [α]	*NC* [Ω]		
Birth to < 21 years + 12 years during adulthood	*‡Do not use this cancer risk unless you have a scenario where children are likely to continue to live in their childhood home as adults.*						

Note: Risk calculations use the Intermediate Exposure MRL provided by ATSDR for soluble uranium salts.
Note: Demographics with increased appreciable risk shown in bold, yellow. Using the Acute Exposure MRL of 0.002 mg/kg/d identifies appreciable risk in identical demographics.

Table 7: Arsenic Exposure Risk Summary

Exposure Group	Site-Specific Scenario *Arsenic (EPC: 0.004 mg/L; Chronic MRL: 0.000 mg/kg/day; CSF: 1.5 (mg/kg/day)$^{-1}$)*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	0.00026	0.00057	0.86	**1.9 †**	**2.8E-5 ‡**	**7.8E-5 ‡**	1
1 to < 2 years	0.00011	0.00031	0.36	**1.0 †**			1
2 to < 6 years	8.6E-05	0.00022	0.29	0.75			4
6 to < 11 years	6.4E-05	0.00018	0.21	0.59			5
11 to < 16 years	4.5E-05	0.00014	0.15	0.46			5
16 to < 21 years	4.3E-05	0.00014	0.14	0.46			5
Total exposure duration for child cancer risk							21
Adult	6.1E-05	0.00015	0.20	0.52	**9.2E-5 ‡**	**2.3E-4 ‡**	78
Pregnant Women	4.8E-05	0.00014	0.16	0.47	*NC Ω*		
Lactating Women	9.1E-05	0.00020	0.30	0.66	*NC Ω*		
Birth to < 21 years + 12 years during adulthood	*‡Do not use this cancer risk unless you have a scenario where children are likely to continue to live in their childhood home as adults.*						

Note: Risk calculations use the Chronic Exposure MRL provided by ATSDR for arsenic.
Note: Demographics with increased appreciable risk shown in bold, yellow.

Table 8: Manganese Exposure Risk Summary

Exposure Group	Site-Specific Scenario *Manganese (EPC: 0.92 mg/L; Chronic RfD: 0.14 mg/kg/day; CSF: NA Using Chronic RfD)*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	0.059	0.13	0.42	0.94	*NC* [Ω]	*NC* [Ω]	1
1 to < 2 years	0.025	0.072	0.18	0.51			1
2 to < 6 years	0.020	0.052	0.14	0.37			4
6 to < 11 years	0.015	0.041	0.11	0.29			5
11 to < 16 years	0.010	0.032	0.074	0.23			5
16 to < 21 years	0.0098	0.031	0.071	0.22			5
Total exposure duration for child cancer risk	-						21
Adult	0.014145	0.036	0.10	0.25	*NC* [Ω]	*NC* [Ω]	78
Pregnant Women	0.010989589	0.033	0.078	0.23	*NC* [Ω]		
Lactating Women	0.021046575	0.045	0.15	0.32	*NC* [Ω]		
Birth to < 21 years + 12 years during adulthood	*‡Do not use this cancer risk unless you have a scenario where children are likely to continue to live in their childhood home as adults.*						

Note: Risk calculations use the Rfd provided by EPA for manganese.
Note: Daily doses do not exceed conservative protective limits.

Table 9: Exposure Risk Summary for Select PFAS Compounds

Analyte	NH Health Limit*	[ATSDR MRL]	Units	Detected		Chronic HQ		Intermediate HQ		Acute HQ		Cancer Risk	
				Max	q95	Max	q95	Max	q95	Max	q95	Max	q95
PFOS	15	14	ng/L	65	9.975	4.6	0.71	4.6	0.71	NC	NC	NC	NC
PFOA	12	21	ng/L	67	16	3.2	0.76	3.2	0.76	NC	NC	≤ 1.0E-6	≤ 1.0E-6
PFHXS	18	140	ng/L	18	8.475	0.13	0.06	0.13	0.06	NC	NC	NC	NC
PFNA	11	21	ng/L	58	4.55	2.8	0.22	2.8	0.22	NC	NC	NC	NC

Note: Using either ATSDR Minimum Risk Level derived drinking water concentrations or NH Health Limits* (set by NH Ambient Groundwater Quality Standards) for risk calculations, daily doses do not exceed conservative protective limits. For individual compounds by demographic see Tables 10-13.

HQ = hazard quotient

Max = maximum concentration detected

q95 = 95% Upper Confidence Interval of the mean

Tables 10-13: Exposure Risk Summaries for Individual PFAS

PFHxS

Exposure Group	Site-Specific Scenario *Perfluorohexane sulfonic acid (PFHxS) (EPC: 8.475E-06 mg/L; Intermediate MRL: 2E-05 mg/kg/day; CSF: NA[3] Using INT MRL [#])*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	5.50E-07	1.20E-06	0.027	0.06			1
1 to < 2 years	2.30E-07	6.60E-07	0.011	0.033			1
2 to < 6 years	1.80E-07	4.80E-07	0.0092	0.024	*NC* [Ω]	*NC* [Ω]	4
6 to < 11 years	1.40E-07	3.70E-07	0.0068	0.019			5
11 to < 16 years	9.50E-08	2.90E-07	0.0048	0.015			5
16 to < 21 years	9.10E-08	2.90E-07	0.0046	0.014			5
Total exposure duration for child cancer risk	-						21
Adult	1.30E-07	3.30E-07	0.0065	0.016	*NC* [Ω]	*NC* [Ω]	78
Pregnant Women	1.00E-07	3.00E-07	0.0051	0.015	*NC* [Ω]		
Lactating Women	1.90E-07	4.20E-07	0.0097	0.021	*NC* [Ω]		

Note: Daily doses do not exceed conservative protective limits.

PFOA

Exposure Group	Site-Specific Scenario *Perfluorooctanoic acid (PFOA) (EPC: 1.6E-05 mg/L; Intermediate MRL: 3E-06 mg/kg/day; CSF: 0.07 (mg/kg/day)$^{-1}$ Using INT MRL [#])*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	1.00E-06	2.30E-06	0.34	0.76	5.3E-9	1.5E-8	1
1 to < 2 years	4.30E-07	1.30E-06	0.14	0.42			1
2 to < 6 years	3.50E-07	9.00E-07	0.12	0.3			4
6 to < 11 years	2.60E-07	7.10E-07	0.086	0.24			5
11 to < 16 years	1.80E-07	5.60E-07	0.06	0.19			5
16 to < 21 years	1.70E-07	5.50E-07	0.057	0.18			5
Total exposure duration for child cancer risk							21
Adult	2.50E-07	6.20E-07	0.082	0.21	1.7E-8	4.3E-8	78
Pregnant Women	1.90E-07	5.70E-07	0.064	0.19	*NC* [Ω]		
Lactating Women	3.60E-07	7.90E-07	0.12	0.26	*NC* [Ω]		

Note: Daily doses do not exceed conservative protective limits.

PFOS

Exposure Group	Site-Specific Scenario *Perfluorooctane sulfonic acid (PFOS) (EPC: 9.975E-06 mg/L; Intermediate MRL: 2E-06 mg/kg/day; CSF: NA[1] Using INT MRL [#])*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	6.40E-07	1.40E-06	0.32	0.71	*NC* [Ω]	*NC* [Ω]	1
1 to < 2 years	2.70E-07	7.80E-07	0.13	0.39			1
2 to < 6 years	2.20E-07	5.60E-07	0.11	0.28			4
6 to < 11 years	1.60E-07	4.40E-07	0.08	0.22			5
11 to < 16 years	1.10E-07	3.50E-07	0.056	0.17			5
16 to < 21 years	1.10E-07	3.40E-07	0.054	0.17			5
Total exposure duration for child cancer risk	-						21
Adult	1.50E-07	3.90E-07	0.076	0.19	*NC* [Ω]	*NC* [Ω]	78
Pregnant Women	1.20E-07	3.50E-07	0.06	0.18	*NC* [Ω]		
Lactating Women	2.30E-07	4.90E-07	0.11	0.25	*NC* [Ω]		

Note: Daily doses do not exceed conservative protective limits.

PFNA

Exposure Group	Site-Specific Scenario *Perfluorooctanoic acid (PFOA) (EPC: 4.55E-05 mg/L; Intermediate MRL: 3E-06 mg/kg/day; CSF: NA Using INT MRL [#])*						
	Chronic Dose (mg/kg/day)		Chronic Hazard Quotient		Cancer Risk		
	CTE	RME	CTE	RME	CTE	RME	ED (yrs)
Birth to < 1 year	2.90E-07	6.50E-07	0.098	0.22	*NC [Ω]*	*NC [Ω]*	1
1 to < 2 years	1.20E-07	3.60E-07	0.041	0.12			1
2 to < 6 years	9.80E-08	2.60E-07	0.033	0.085			4
6 to < 11 years	7.30E-08	2.00E-07	0.024	0.067			5
11 to < 16 years	5.10E-08	1.60E-07	0.017	0.053			5
16 to < 21 years	4.90E-08	1.60E-07	0.016	0.052			5
Total exposure duration for child cancer risk	-						21
Adult	7.00E-08	1.80E-07	0.023	0.059	*NC [Ω]*	*NC [Ω]*	78
Pregnant Women	5.40E-08	1.60E-07	0.018	0.054	*NC [Ω]*		
Lactating Women	1.00E-07	2.20E-07	0.035	0.075	*NC [Ω]*		

Note: Daily doses do not exceed conservative protective limits.

Appendix C: Calculations, Exposure Parameters and Exposure Factors

Contaminants of concern were evaluated further using ATSDR's online Public Health Assessment Site Tool (PHAST). Concentrations were entered as 95% of the concentration mean, and intake rate (IR), exposure factor (EF) and body weight (BW) were entered as default fault values described in ATSDR's Exposure Dose Guidance for Water Ingestion and summarized in the tables below. These equations yield an exposure dose (D) in milligrams per kilogram per day (mg/kg)/day for each population demographic listed, which is compared to a corresponding protective dose as described in each scenario. For example, this corresponding protective dose is often an ATSDR MRL, EPA MCL, or State of New Hampshire guidance value for AGQSs.

ATSDR Comparison Values

ATSDR CVs are media-specific concentrations used to screen and identify contaminants that require additional evaluation due to concern for health risks CVs can be based on either carcinogenic or non-carcinogenic effects (Agency for Toxic Substances and Disease Registry, 2018). CVs based on carcinogenic effects account for a lifetime exposure with a calculated excess lifetime cancer risk of one extra case per one million exposed people. When a cancer and non-cancer CV exists for the same chemical, the lower of these values is used in the data comparison to ensure a more protective assessment.

CVs are derived using standard default exposure assumptions and are not site-specific. For contaminants detected below their respective CVs, exposure is not anticipated to result in adverse health effects. Contaminants detected at concentrations that exceed their respective CVs, do not necessarily represent a health threat**.** For oral exposure, non-cancer health effects are evaluated with either Environmental Media Exposure Guides (EMEGs) or MRLs and cancerous effects with Cancer Risk Evaluation Guides (CREGs). CVs for the concentrations of contaminants of concern are presented in Table 5*. Water contaminant concentrations that exceeded at least one CV were evaluated quantitatively.* Doses used in PHAST default to the most protective EMEG or CREG for all scenarios considered.

ATSDR MRLs for Uranium and Radon

- **Uranium:** An MRL of (0.002 mg/kg)/day has been derived for acute-duration oral exposure (≤15 days) to soluble compounds of uranium.
- An MRL of 0.0002 (mg/kg)/day has been derived for intermediate-duration oral exposure (15– 364 days) to soluble compounds of uranium.
- Derivation of an MRL using the NOAEL of (54 mg/kg)/day identified in the two-year uranyl fluoride rat study (Maynard and Hodge 1949; Maynard et al. 1953) as the point of departure was considered; the NOAEL/LOAEL approach was used because the lack of incidence data for most exposure groups precluded using benchmark dose analysis to identify a point of departure. Using this point of departure would result in a MRL that is higher than the intermediate-duration oral MRL for uranium; thus, a chronic-duration oral MRL has not been derived (Agency for Toxic Substances and Disease Registry, 2013).
- Due to lack of consistent drinking water MRL toxicity data in humans, ATSDR recommends using EPA's MCL of 30 µg/L for exposure comparison.

- **Radon:** No acute-, intermediate-, or chronic-duration oral MRLs have been derived for radon due to a lack of suitable human or animal data regarding health effects following oral exposure to radon and its progeny (Agency for Toxic Substances and Disease Registry, 2012)
- As both uranium and radon are radioactive, naturally-occurring environmental elements with limited CVs, ATSDR subject matter experts were invited to review the sampling data and provide recommendations for public health implications. ***All radionuclides are considered potentially carcinogenic***, although the radioactivity of naturally-occurring uranium and radon is low.

Exposure Parameters

Water Ingestion Exposure Dose Equation

D = (C * IR * EF) / BW

D = Exposure Dose (mg/kg)/day, C = Contaminant Concentration (mg/L), IR = Intake Rate (L/day), EF = Exposure Factor (unitless), BW = Body Weight (kg)

Exposure Group	Body Weight (kg)	Age-Specific Exposure Duration (years)	Intake Rate (L/day)		
			CTE (Central Tendency Exposure)	RME (Reasonable Maximum Exposure)	Custom
Birth to < 1 year	7.8	1	0.504	1.11	
1 to < 2 years	11.4	1	0.308	0.893	
2 to < 6 years	17.4	4	0.376	0.977	
6 to < 11 years	31.8	5	0.511	1.4	
11 to < 16 years	56.8	5	0.637	1.98	
16 to < 21 years	71.6	5	0.770	2.44	
Adult	80	78	1.23	3.09	
Pregnant Women	73	NA	0.872	2.59	
Lactating Women	73	NA	1.67	3.59	

Exposure Factors

Duration	Days	Weeks	Years	Non-Cancer Exposure Factor	
Acute				1	**EF cancer** = EF non-cancer x Age-Specific Exposure Duration (years)/78 years
Intermediate	7			1	
Chronic	7	52.14	78	1	

Keys for All Output Tables

§ Cancer risk (CR) is derived for both CTE (12 years) and RME (33 years) residential occupancy periods. For children, CRs are derived for a combined child receptor: CTE (12 years) and RME (21 years) at a given residence. For the CTE child CR, the combined child is the sum of the cancer risks for each age group for the first 12 years of exposure only. The RME CR for the combined child is derived by summing all the cancer risks for each age group from birth to < 21 years. The adult CR assumes living at the residence for 12 (CTE) or 33 (RME) years. Cancer risks can be calculated for contaminants with cancer slope factors stored in PHAST.

† Hazard Quotients are greater than 1. The health assessor should conduct further toxicological evaluation.

‡ Cancer risk is greater than 1.0E-6. The health assessor should conduct further toxicological evaluation.

Ω Cancer risks are not calculated for pregnant women and lactating women. Their cancer risks are similar to an adult woman exposed for 33 years. If you would like to calculate cancer risks for pregnant women and lactating women, enter site-specific scenarios.

1 Carcinogen; No cancer slope factor (CSF); See CVs and Health Guidelines Module for additional cancer class information.

3 Carcinogenicity not determined; Cancer risk was not calculated.

Appendix D: Additional Resources

1. "Be Well Informed" – Information and Guidance for Treating Your Well Water
2. General link to Drinking Water Quality Information (includes relevant information and links to factsheets on arsenic, radionuclides/uranium and other contaminants)
3. New Hampshire Department of Human Services Radon Program
4. EPA Radon Program
5. Cost Effective Air Radon Testing:

   American Lung Association Radon Basics

   National Radon Program Services
6. NH PFAS Investigation (includes information about ongoing investigations, water testing and water treatment options)
7. ATSDR PFAS FAQs
8. NHDES PFAS Sampling Results Data Viewer