



HEI Research Report 233

Hydrocarbon Extraction and Risk to Groundwater in Pennsylvania: Part 2. An Analysis of Water Quality in the Oldest Hydrocarbon Basin in the United States

Jennifer Baka et al.

Additional Materials 4: Analysis of Sampled Water Additional Materials 4a: Cover Letter Template Additional Materials 4b: Additional Cover Letter Language for Analytes Above MCLS/SMCLS/Detection Limits

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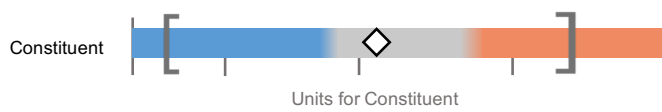
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Additional Materials 4: Analysis of Sampled Water (Graphical Results)

Sample ID#:	EXAMPLE
Date of Sampling:	Date

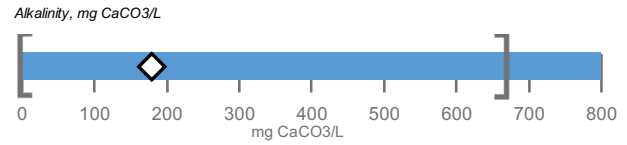
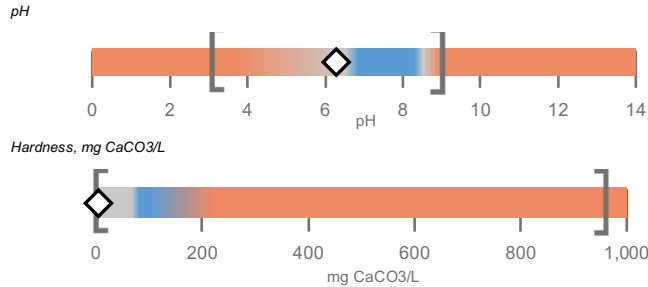
Reading the Graphs:



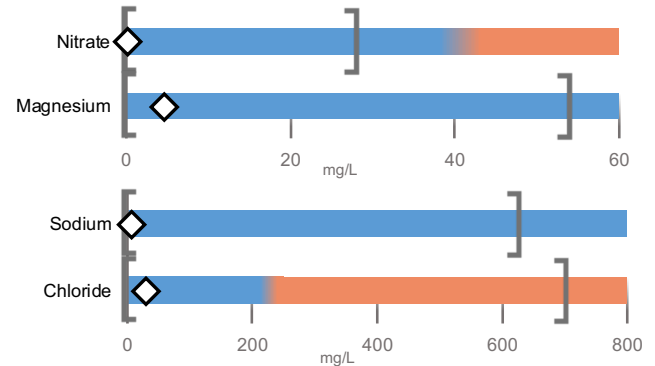
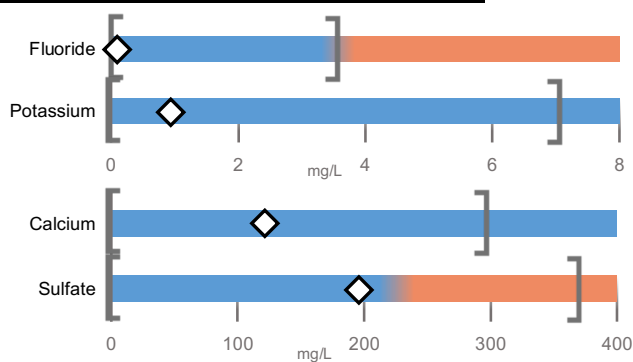
◇ Your result [Range of Values for Project Samples]

Blue: Within standard / No standard implemented
 Grey: Above warning level, below actionable level
 Orange: At or above action level

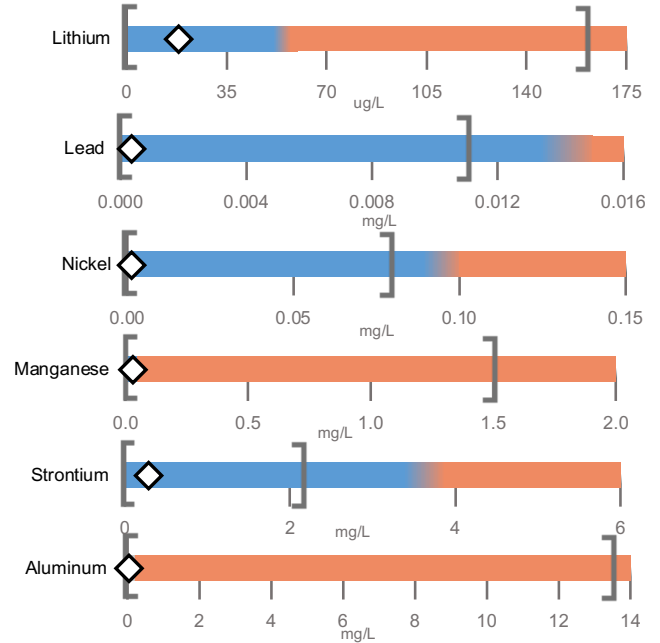
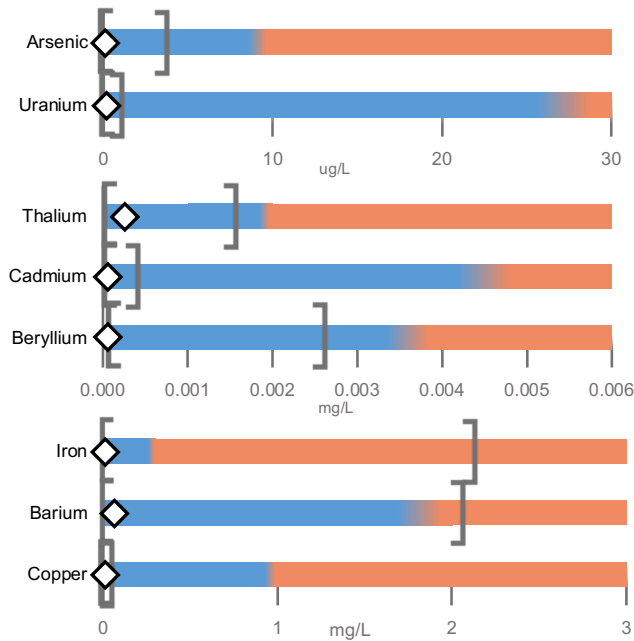
Select Measurements and Parameters



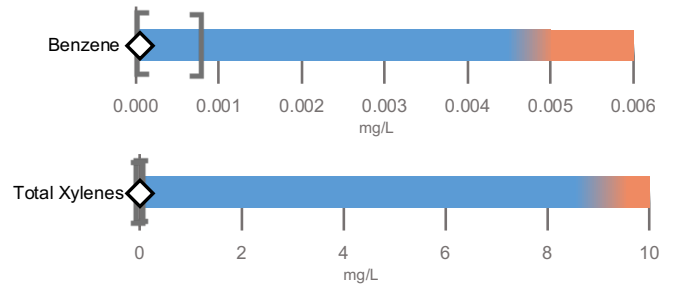
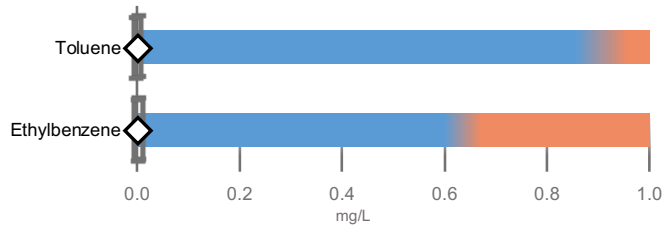
Major Anions and Cations



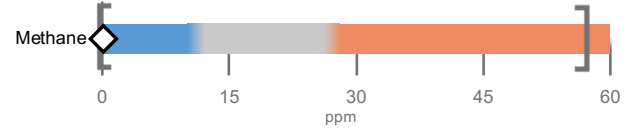
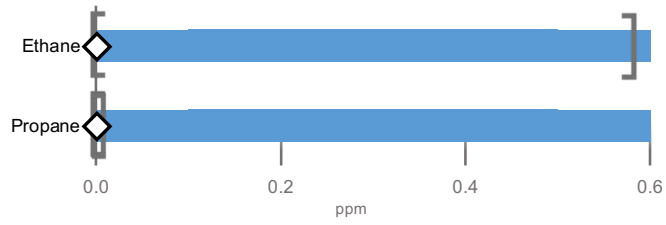
Trace Metals



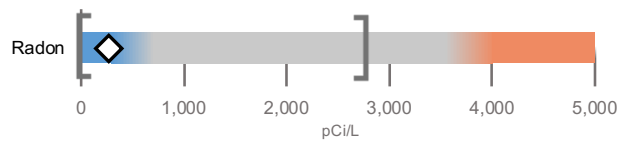
Volatile Organic Carbons (VOCs)



Dissolved Gasses



Radioactivity



Additional Materials 4b: Analysis of Sampled Water (Table of Results)

Sample ID#:	EXAMPLE									
Date of Sampling:	Date									
	Included in Graphs (✓)	Measured Value	Units	Water Quality Standard Value	Units	Source and Type of Standard	Common Remediation Methods			
							Aeration	Water Softener	Granulated Activated Carbon	Reverse Osmosis
Selected Measurements and Parameters										
pH	✓	6.27	pH units	6.5 to 8.5	pH units	EPA National Secondary Drinking Water Level				
Temperature		12.9	oC							
Specific Conductivity		682	uS/cm							✓
Dissolved Oxygen		5.13	mg/L							
Hardness	✓	3.98	mg CaCO3/L	800-1000	mg CaCO3/L	Safe Drinking Water Foundation Guideline		✓		✓
Alkalinity	✓	178	mg CaCO3/L					✓		✓
Methane Detection in Air		0	ppm				✓			
Major Anions and Cations										
Bromide		0.02	mg/L	6 (2)	mg/L	WHO Recommendation, Adults (Children)				✓
Calcium	✓	121	mg/L					✓		✓
Chloride	✓	28.4	mg/L	250	mg/L	EPA National Secondary Drinking Water Level				✓
Dissolved Inorganic Carbon		52.7	mg C/L							✓
Fluoride	✓	0.09	mg/L	4	mg/L	EPA Primary Maximum Concentration Level (MCL)				✓
Magnesium	✓	4.51	mg/L					✓		✓
Nitrate-NO3	✓	0.12	mg/L	45	mg/L	EPA Primary Maximum Concentration Level (MCL)				✓
Phosphorus		0.21	mg/L							✓
Potassium	✓	0.93	mg/L							✓
Silicon		4.86	mg/L							✓
Sodium	✓	6	mg/L							✓
Sulfate	✓	195.00	mg/L	250	mg/L	EPA National Secondary Drinking Water Level				✓
Trace Metals										
Aluminum	✓	0.02	mg/L	0.05 to 0.2	mg/L	EPA National Secondary Drinking Water Level				✓
Arsenic	✓	<0.05	ug/L	10	ug/L	EPA Primary Maximum Concentration Level (MCL)				✓
Barium	✓	0.06	mg/L	2	mg/L	EPA Primary Maximum Concentration Level (MCL)		✓		✓
Beryllium	✓	0.00005	mg/L	0.004	mg/L	EPA Primary Maximum Concentration Level (MCL)				✓
Cadmium	✓	0.0001	mg/L	0.005	mg/L	EPA Primary Maximum Concentration Level (MCL)				✓
Copper	✓	0.003	mg/L	1	mg/L	EPA National Secondary Drinking Water Level		✓	✓	✓
Iron	✓	0.005	mg/L	0.3	mg/L	EPA National Secondary Drinking Water Level		✓		✓
Lead	✓	0.0003	mg/L	0.015	mg/L	EPA Primary Maximum Concentration Level (MCL)			✓	✓
Lithium	✓	17.9	ug/L	60	ug/L	USGS Drinking Water Benchmark				✓
Manganese	✓	0.03	mg/L	0.05	mg/L	EPA National Secondary Drinking Water Level		✓	✓	✓
Nickel	✓	0.0010	mg/L	0.1	mg/L	EPA Health Reference Level or Health Advisory Level				✓
Strontium	✓	0.280	mg/L	4	mg/L	EPA Health Reference Level or Health Advisory Level		✓		✓
Thallium	✓	0.0003	mg/L	0.002	mg/L	EPA Primary Maximum Concentration Level (MCL)				✓
Uranium	✓	0.17	ug/L	30	ug/L	EPA Primary Maximum Concentration Level (MCL)				✓
Volatile Organic Carbons (VOCs)										
Benzene	✓	0.0000	mg/L	0.005	mg/L	EPA Primary Maximum Concentration Level (MCL)	✓		✓	✓
Ethylbenzene	✓	0.0001	mg/L	0.7	mg/L	EPA Primary Maximum Concentration Level (MCL)	✓		✓	✓
Toluene	✓	0.0001	mg/L	1	mg/L	EPA Primary Maximum Concentration Level (MCL)	✓		✓	✓
Xylenes (total)	✓	0.0002	mg/L	10	mg/L	EPA Primary Maximum Concentration Level (MCL)	✓		✓	✓
Dissolved Gasses										
Ethane, dissolved	✓	0.0001	ppm				✓			
Methane, dissolved	✓	0.0001	ppm	10 to 28	mg/L	Department of Interior Warning Level	✓			
Propane, dissolved	✓	0.0002	ppm				✓			
Radioactivity										
Radon 222	✓	257	pCi/L	300-4,000	pCi/L	EPA Action Level or Recommended Maximum	✓		✓	

Additional Materials 4a: Cover Letter Template



PennState

Department of Geography
College of Earth and Mineral Sciences
The Pennsylvania State University
302 Walker Building
University Park, PA 16802-6802

814-865-3433
Fax: 814-863-7943

Date

Dear [Participant],

Thank you for participating in our research study. Please find the results of your water testing included. You will find:

1. Visualizations of your results that compare your individual results to:
 - a. existing water standards, if they exist, and
 - b. to the range of values measured in Beaver, Washington and Greene counties
2. A table summarizing your results

There are some results that I wanted to bring to your attention.

Please note that we sampled your water before it went through any treatment systems you may have installed at your home. Thus, the water testing results presented in this packet do not necessarily reflect what you are drinking.

Please also note that we conducted the water testing at Penn State University. These laboratories are not considered certified laboratories for legal proceedings.

We will be hosting a series of community meetings to share the results of the project early in 2025. I will be in touch with you to share the dates and venues, once they have been set.

My team and I are happy to answer any questions you might have about your results.

You can leave me a voicemail by calling me at 814-865-9656 or emailing me at jeb525@psu.edu.

Thank you again for participating in our study.

Best wishes,

A handwritten signature in black ink, appearing to read 'Jennifer Baka'.

Dr. Jennifer Baka
Associate Professor, Department of Geography
Earth and Environmental Systems Institute Faculty Associate
The Pennsylvania State University

Additional Materials 4b:Additional Cover Letter Language for Analytes Above MCLs/SMCLs/Detection Limits

Note, the cover letter (B.1) included additional language for each analyte above an MCL/SMCL/detection limit. The list below is the entire list of analytes but cover letters only included language for the specific analytes from their water tests above MCLs/SMCLs/detection limits.

Barium

Barium was present in your water at **xx** mg/L. Barium is naturally occurring and commonly found in groundwater. Barium is also present in oil and gas drilling wastes. The US EPA has set the primary maximum contaminant level (MCL) for barium at 2 mg/L. MCLs are legally enforceable standards for public water systems in the USA that are intended to improve public health by limiting the levels of contaminants that cause harm. Potential short-term health effects from exposure to barium include gastrointestinal disturbances and muscular weakness. Potential long-term health effects from exposure to barium include elevated blood pressure and adverse effects on kidneys ([CDC Barium](#)). You can read more about barium in public drinking water systems at this URL: [EPA MCLs](#)

If you are interested in removing barium from your water, potential remediation measures include a reverse osmosis or water softening system. For more information, see: [Barium Removal](#), [EPA Barium](#). If you would like additional assistance on further water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

Fluoride

Fluoride was present in your water at **xx** mg/L. Fluoride can occur naturally in groundwater and is sometimes added at low concentrations to public water supplies as a cavity prevention measure. The EPA has established a secondary maximum contaminant level (SMCL; SMCLs are non-enforceable guidelines) for fluoride at 2 mg/L and a primary MCL of 4 mg/L, but these values are currently being evaluated and could change. Elevated fluoride can cause tooth discoloration and bone tenderness and pain. SMCLs are recommended guidelines established to assist public water authorities with managing aesthetic characteristics of drinking water, such as taste, color, and odor. You can read more about fluoride in drinking water here: [PA DEP Fluoride](#).

If you are interested in removing fluoride from your drinking water, potential remediation measures include a reverse osmosis system, which can be installed under your kitchen sink. For more information on reverse osmosis systems to remove fluoride, please see: [Fluoride reverse Osmosis](#).

If you would like additional assistance on further water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

Chloride

Chloride was present in your water at **xx** mg/L. Chloride is commonly found in groundwater but can be found at higher concentrations because of human activities, including salting of roads for ice mitigation. Chloride is also a constituent in wastes from oil and gas development. The EPA has established a secondary maximum contaminant level (SMCL) for chloride at 250 mg/L. Above the SMCL, chloride can give water a salty taste that may be objectionable. Elevated chloride can also cause corrosion within pipes, leading to elevated lead and copper in drinking water. SMCLs are recommended guidelines established to assist public water authorities with managing aesthetic characteristics of drinking water, such as taste, color, and odor. You can read more about SMCLs at this URL: [EPA SMCLs](#).

If the taste of your water is objectionable, potential remediation measures include a reverse osmosis system. For more information, see: [Penn State Extension Chloride](#)

If you would like additional assistance on further water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

Bromide

Bromide was present in your waters at **xx** mg/L. Bromide is a natural constituent of groundwater and bedrock but can also be associated with wastewater produced by fossil fuel extraction and utilization. Many man-made chemicals also contain bromide compounds. Bromide has been used medicinally for more than 100 years and has low toxicity to humans except at very high levels ([EPA Vanbriesen](#)). The EPA Ambient Surface Water Quality recommendation for bromide in drinking water is 2 mg/L, calculated to prevent bioaccumulation of bromide to toxic levels ([EPA Ambient Standards](#)).

If you are interested in removing bromide from your water, potential remediation measures include a reverse osmosis system. For more information on removing Bromide using a Reverse Osmosis filter, please see: [Bromide RO](#).

If you would like additional assistance on further water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

Total Dissolved Solids

We calculated the TDS in your water to be at least **xx** mg/L. Total dissolved solids (TDS) is a measure of the total amount of inorganic matter dissolved in your water. The EPA has established a secondary maximum contaminant level (SMCL) for TDS at 500 mg/L. Above the SMCL, TDS can potentially leave deposits on your plumbing fixtures and pipes, cause staining, or give the water an objectionable color or taste. SMCLs are recommended guidelines established to assist public water authorities with managing aesthetic characteristics of drinking water, such as taste, color, and odor. You can read more about SMCLs at this URL: [EPA SMCLs](#).

If the taste, color, or residues of your water are objectionable, you may want to consider remediation measures for your water system. Potential options include a reverse osmosis or a water softening system. For more information, please see: [EPA TDS](#)

If you would like additional assistance on further water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

Methane

The sample results showed methane present at **xx mg/L** in your water. Methane is the principal gas in natural gas, i.e. the gas used in stoves and cooktops, and is also a common gas that is produced naturally in some ground waters. Federal water standards have not been set for methane in drinking water. Dissolved methane in water can start degassing into the air when the concentration is above 0.00005 mg/L. But 28 mg/l has been noted as a level of concern that requires immediate action. If methane degasses from drinking water and builds up in your house or basement, there is a possibility of a fire or an explosion. Natural gas can also cause asphyxiation in rare circumstances, i.e., if it builds up to extremely high concentrations in air. When the PA Department of Environmental Protection (DEP) learns of methane concentrations in domestic water greater than 7 mg/L, they notify the owner of the hazards so that the homeowner can mitigate the problem.

Please note that methane concentrations in home waters vary with weather, time of year, and water usage, among other factors. The level of methane in your water might vary greatly compared to the one analysis we did for you. Note that the DEP recommends that all water wells be equipped with a working vent to alleviate the concentration of flammable gases such as methane. However, even a vent does not eliminate all possibility of hazard.

Based on the methane concentration in your water, we suggest you should consider mitigation procedures to remove methane safely from your water.

If you would like additional assistance on additional water testing or mitigation procedures, we suggest that you contact the SW PA DEP office at 412-442-4281.

For more information on methane in groundwater and mitigation procedures, these documents will provide more information:

Penn State Extension: [PSU extension Methane Removal](#)

PA DEP: <https://www.pa.gov/content/dam/copapwp-pagov/en/health/documents/topics/documents/environmental-health/Methane.pdf>

When waters do not meet National Secondary Maximum Contaminant Levels (SMCLs) for pH, sulfate, iron (Fe), manganese (Mn), and aluminum (Al)

In your water, aluminum, iron, and manganese were present at xxx mg/L, yyy mg/L, and zzz mg/L respectively. Presently, there are no Primary Drinking Water Standards for pH, sulfate, iron, manganese and aluminum in drinking water. However, the EPA has established Secondary Maximum Contaminant Levels (SMCLs) for these analytes. The EPA does not enforce standards for SMCLs, unlike primary drinking water standards. Instead, SMCLs are meant to assist public water systems with managing their drinking water for aesthetic considerations, such as taste, color, and odor. These contaminants are not considered to present a risk to human health at the SMCL.

If the taste, color, or odor of your water is objectionable and your water does not meet the SMCLs for pH (6.5 - 8.5), sulfate (<250 mg/L), iron (<0.3 mg/L), manganese (<0.05 mg/L), or aluminum (<0.2 mg/L), you may want to consider some mitigation activities.

Low pH levels may be of particular concern because low pH water is acid. Note, however, that the pH of many popular soda drinks are extremely acidic, so low pH in and of itself is not necessarily problematic (i.e. < pH 3). The reason low-pH drinking water can be problematic is that it can dissolve many metals from rocks and pipes, some of which could be of concern. For example, water with a pH of less than 6.5 or greater than 8.5 can dissolve lead and copper from plumbing fixtures.

These values exceed the SMCLs of 0.2 mg/L (aluminum), 0.3 mg/L (iron), and 0.05 mg/L (manganese). Iron and manganese are commonly found in Pennsylvania in private water systems because they are in almost all rocks through which the groundwater flows. The presence of iron and manganese in home waters has been associated with red staining or black staining, respectively. The final table accompanying your water testing results documents common remediation methods that can reduce the levels of sulfate, iron, manganese, or aluminum in drinking water.

You can read more about these secondary levels at this url: [EPA SMCLs](#).

Radon

Radon levels in your water levels measured at XYZ. Radon is a noble gas and has no discernable odor. It is common to find radon dissolved in groundwater. There is currently no EPA drinking water standard for radon and radon in private groundwater wells is not regulated. EPA has proposed an MCL of about 4,000 pCi/L assuming action is taken to reduce radon levels in indoor air. If no radon mitigation action is taken, then a lower MCL of 300 pCi/L is proposed. This is because most of the radon in a home comes from soil under the foundation. Radon can be removed from the water using either a granular activated carbon (GAC) filter or an aeration system that bubbles air through the water, allowing the radon gas to escape and be vented outdoors.

If your radon is elevated above 300 pCi/L in your groundwater it could indicate that radon is also elevated in your indoor air. When water with radon enters the home, the radon can escape the water and enter the air. Radon can also naturally leave the soil and rocks beneath the home and accumulate in the indoor air. If inhaled in large quantities, the radon particles can deposit on the cells lining human airways, causing negative health impacts. Home test kits for air can be purchased at home improvement stores, but it may be best to hire a state-certified company to test your indoor air. If the levels are elevated in the air, you can have a certified contractor install a radon reduction system. If you already have a home radon mitigation system that functions no further action is likely necessary.

Lithium

The level of lithium measured in your sample was ABC µg/L. Lithium is a very common element that is not currently regulated in drinking water by the EPA. Lithium has been associated with some health issues when present at high concentrations but is also used as a drug for some disorders and has been shown to have some human health benefits. The U.S. Geological Survey (USGS) reports a non-enforceable health-based screening level of 10 µg/L (Smith and Nowell 2024) or 60 µg/L if the drinking water is the only source of Li to a person's diet (Lindsey et al 2021). A large fraction of public-supply water wells and domestic wells show concentrations of lithium at these levels. Given that the health effects of lithium are largely unexplored, mitigation for this element may not be warranted. However, some ion exchange or reverse osmosis systems can lower lithium concentrations in drinking water. You can read more about lithium in drinking water from the EPA document: [EPA lithium](#)

Links

Smith and Nowell 2024: <https://water.usgs.gov/water-resources/hbsl/>

Lindsey et al 2021: <https://www.sciencedirect.com/science/article/pii/S0048969720382243?via%3Dihub>

EPA lithium: <https://www.epa.gov/system/files/documents/2023-11/ucmr5-technical-fact-sheet-lithium-in-drinking-water.pdf>

EPA SMCLs: <https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals>

EPA TDS: <https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals>

Penn State Extension Chloride: <https://extension.psu.edu/tips-for-buying-water-treatment-equipment>