Health Consultation

Public Health Evaluation of Water Data
Collected in the Vicinity of the JKLM Natural Gas Well
on the Reese Hollow 118 Pad

COUDERSPORT, POTTER COUNTY, PENNSYLVANIA

NOVEMBER 15, 2018

COMMENT PERIOD ENDS: JANUARY 15, 2019

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from 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 material. 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 exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This 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.

HEALTH CONSULTATION

PUBLIC COMMENT VERSION

Public Health Evaluation of Water Data Collected in the Vicinity of the JKLM Natural Gas Well on the Reese Hollow 118 Pad

COUDERSPORT, POTTER COUNTY, PENNSYLVANIA

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Heath Investigations
Eastern Branch
Atlanta, Georgia 30333

Contents

Tables

Figures

Appendices

Acronyms and Definitions

95UCL	Calculated value that equals or exceeds an exposure unit's actual arithmetic mean of site concentrations 95 percent of the time
ADI	Acceptable Daily Intake
AI	Acceptable intake
aEMEG	Acute duration environmental media evaluation guideline
ATSDR	Agency for Toxic Substances and Disease Registry, CDC, DHHS
BLL	Blood lead level
CDC	U.S. Centers for Disease Control and Prevention
cEMEG	Chronic duration environmental media evaluation guideline
CNS	Central nervous system
COPC	Contaminant of potential concern
CREG	Cancer risk evaluation guideline
CTE	Central tendency exposure concentration
CV	ATSDR health-based comparison value
CWTP	Coudersport Water Treatment Plant
DCHI	ATSDR Division of Community Health Investigations
DEHP	Di-ethylhexyl phthalate or bis-2(ethylhexyl)phthalate
DHHS	U.S. Department of Health and Human Services
DOI	U.S. Department of the Interior
DWEL	EPA Drinking Water Equivalent Level (non-regulatory)
E. Coli/ *E. coli*	Escherichia coli; bacteria
EEG	Electroencephalogram
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
F-485	A surfactant product used by natural gas drillers containing proprietary chemicals and 10% isopropanol
FAO	Food and Agriculture Organization of the United Nations
GI	Gastro-intestinal
HA	Health Advisory
HI	Hazard Index
HQ	Hazard quotient
IARC	International Agency for Research on Cancer
iEMEG	Intermediate duration environmental media evaluation guideline
iMRL	Intermediate duration minimal risk level
IOM	Institute of Medicine
JKLM	JKLM Energy, LLC – n independent oil and natural gas exploration and production company
kg	Kilogram
LOAEL	Lowest observed adverse effect level
LOD	Limit of detection (the lowest or highest concentration that can be detected by the laboratory)
MBAS	Methylene blue active substance – a colorimetric test for surfactants
MCL	Maximum contaminant level
MCLG	EPA maximum contaminant level goal
mg/day	milligrams per day
mg/L	Milligrams per liter
MPN/100 ml	Most probable number of colony forming units per 100 milliliters of water
MRL	ASTDR minimal risk level
MSC	Medium specific concentration
NA	Not available
NC	Not calculated
NOAEL	No observed adverse effect level

OEHHA	California Office of Environmental Health Hazard Assessment
PADEP	Pennsylvania Department of Environmental Protection
PADOH	Pennsylvania Department of Health
pH	A scale of acidity from 0 to 14
PPRTV	EPA Provisional Peer-Reviewed Toxicity Value
p-RfD	Provisional EPA reference dose
RfD	EPA reference dose
RME	reasonable maximum exposure concentration
RMEG	ATSDR comparison value based on EPA reference dose
RSL	EPA regional screening level
RW	Residential well
SMCL	EPA secondary maximum contaminant level
TWA	Time-weighted average
UL	Institute of Medicine tolerable upper intake limit
USGS	U.S. Geological Survey
USDA	U.S. Department of Agriculture
WHO	World Health Organization
µg/day	Micrograms per day
µg/L	Micrograms per liter

Summary

Introduction	In September 2015, JKLM Energy, LLC, (JKLM) injected chemicals into an open wellbore at Reese Hollow 118 well pad. The Pennsylvania Department of Environmental Protection (PADEP) and JKLM investigated this incident. Injected and naturally-occurring chemicals were documented in drinking water supplies near the site. Over 100 drinking water sources were sampled during the response. The drinking water sources that were sampled included private and public groundwater wells and springs. Surface water (ponds) near the site not used for drinking water were also sampled. PADEP determined that, of 17 private water supply complaints and over 100 samples from individual water sources, six drinking water sources were impacted by the JKLM release (PADEP 2016). The Agency for Toxic Substances and Disease Registry (ATSDR) accepted a petition to review the available environmental data related to this incident to assess the public health implications of exposures to impacted water in the area.
Conclusions	**Based on the available data, ATSDR concludes the plume of contamination due to the JKLM release was diluted and degraded quickly in the aquifer.** **A limited number of drinking water wells and surface water bodies were directly impacted by the release for less than six months.** **Exposures to JKLM-related chemicals in drinking water were of short duration and at concentrations where *most* exposures were not expected to result in adverse health effects. Exposures to one JKLM-related chemical in one private groundwater well were high enough to cause temporary adverse health effects at one residence via inhalation while showering.** **Surfactants were detected in surface water bodies (creeks and ponds), but at lower concentrations than were detected in groundwater sources. Only a small number of groundwater sources had surfactant detections. Surfactants are compounds used in soaps, detergents, lubricants, and other emulsifiers.** ATSDR reached three specific conclusions related to exposures to chemicals and one conclusion related to exposure to bacteria in drinking water in the Coudersport area:
Conclusion 1	**Isopropanol was detected in three private groundwater wells. The maximum level of isopropanol detected in one of these private wells was high enough to be of health concern from inhalation exposures during household water use (e.g., showering). The levels of isopropanol in the two other wells were below concentrations where health effects may be expected. Isopropanol is a contaminant that was released to groundwater by JKLM during this incident.**

Basis for Conclusion 1	Based on the available sampling data, people were only exposed to isopropanol in their drinking water supplies for a short time. ATSDR does not expect any adverse health effects from *drinking* the levels of isopropanol detected for a short period of time in any of the three private wells with detections of this chemical. Based on results from a computer-based shower model that uses chemical concentrations in water, estimated *inhalation* exposure concentrations (showering plus bathroom time), for one residence with the maximum level of isopropanol exceeded an acute inhalation screening level. Temporary health effects, including eye, nose, and throat irritation, may have occurred from acute exposures to isopropanol at this residence. People with diabetes, and/or pre-existing eye, skin, respiratory, or neurological conditions, could be more sensitive to this chemical exposure. We expect some variability in people's responses to breathing this modeled level of isopropanol in air. While some individuals might experience short-term health effects at this maximum exposure level detected, others may not. Isopropanol detected in other wells were not detected at concentrations of health concern from inhalation or ingestion.
Conclusion 2	**People who consumed water contaminated with bromide, iron, lead, lithium, manganese or sodium may be at risk for harmful non-cancer health effects associated with these chemicals.**
Basis for Conclusion 2	**<u>Bromide</u>**: Levels of bromide in three drinking water sources exceeded the World Health Organization (WHO) acceptable daily intake (ADI) level for bromide. However, estimated exposure doses were below the conservative no observed adverse effect level (NOAEL) of 4 milligrams per kilogram per day (mg/kg/day). **<u>Iron</u>**: Water samples from 12 drinking water sources exceeded the EPA regional screening level (RSL) of 1,400 micrograms per liter (µg/L) and twenty-nine drinking water sources exceeded the EPA secondary maximum contaminant level (MCL) of 300 µg/L. Exposures to the higher iron concentrations found in the 12 drinking water sources are not likely to result in adverse health effects in healthy residents. However, individuals with hemochromatosis, a rare inherited disease, may be at risk from these increased iron exposures from drinking water. **<u>Lead</u>**: Lead in drinking water at any level should be reduced or removed. Fifty-six (56) of the Coudersport drinking water sources had detectable levels of lead, nineteen of which exceed the EPA action level for public drinking water of 15 µg/L. Chronic exposure to low lead levels in children has been shown to cause effects on the central nervous system, which can result in deficits in intelligence, behavior, and school performance. Health effects from lead exposure in children and unborn fetuses include

	both physical and mental impairments, hearing difficulties, impaired neurological development, and reduced birth weights and gestational age. **Lithium**: Seven drinking water sources had lithium detections exceeding the EPA RSL of 40 μg/L. There is very little toxicological data on lithium exposures in young children. The potential for adverse health effects in sensitive subpopulations (patients undergoing lithium treatment, children, pregnant women, people with significant renal or cardiovascular disease, or individuals susceptible to dehydration or sodium depletion with concurrent long-term use of medications) is uncertain because of the lack of relevant study data. **Manganese:** Manganese concentrations exceeded health based screening values in six drinking water sources. Chronic child and adult manganese exposure doses at one private drinking water well exceeded the lowest observed adverse effect levels (LOAEL). Chronic manganese exposure doses at two other private drinking water wells, when including additional exposures to manganese from food sources, exceeded the LOAEL for children under three. The EPA short-term advisory level is exceeded for adults consuming water from two private drinking water wells and for children consuming water from five private drinking water wells. High levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember. **Sodium**: Exposures to sodium from Coudersport drinking water sources sampled at this site (without consideration of additional sodium intake from food sources) do not exceed recommended U.S. Departments of Health and Human Services and Agriculture (HHS/USDA) dietary guideline of 2,300 mg/day. However, twenty-three (23) drinking water sources exceeded the EPA drinking water advisory level for sodium (20 mg/L) in public drinking water. Individuals on sodium restricted diets or individuals with infants drinking this water should discuss their drinking water sodium results with their physician.
Conclusion 3	**Health effects are not expected from exposures to other chemicals assessed in Coudersport area drinking water sources.**
Basis for Conclusion 3	Although concentrations of **acetone, aluminum** and **barium** in Coudersport drinking water exceeded health-based screening values, ATSDR's analysis of the calculated daily exposure doses for each of these chemicals were below minimal risk levels (MRL) for both children and adults. An MRL is a daily exposure dose below which health effects are not expected to occur. The one-time **benzene** detection in drinking water was below the EPA 10-day health advisory level. All other assessed chemicals were below health-based screening values.

Next Steps for Conclusions 1-3	**<u>General Recommendations</u>** *Install treatment and continue to monitor*: ATSDR recommends that private well owners with elevated levels of lead, lithium, manganese or sodium take steps to reduce exposures to these chemicals in their drinking water. This includes working with water quality treatment professionals to install treatment systems specifically designed to remove these contaminants. In addition, ATSDR recommends that all private well owners continue to monitor the quality of their residential well water. The Penn State Extension Program provides low cost well testing and offers a specific gas/oil water testing package. Further information on Penn State's private water well testing program can be obtained from the Potter County Penn State Extension Office (814-274-8540; PotterExt@psu.edu) or the Penn State Extension Lab Testing website (http://agsci.psu.edu/aasl/water-testing). Penn State has also developed a fact sheet with specific recommendations for analytes appropriate to include in drinking water testing; the fact sheet can be found at: http://extension.psu.edu/natural-resources/water/marcellus-shale/drinking-water/testing-drinking-water-supplies-near-gas-drilling-activity/extension_publication_file. *Health Education/Outreach*: In early 2016, soon after accepting the petition, ATSDR attempted to notify all residents with detected fecal coliform/E.coli contamination in their water supplies and residents with lead concentrations in their drinking water above the EPA public water supply action level of 15 µg/L. However, the contact information obtained by ATSDR was limited to a few residents in this rural area. ATSDR is working with PADEP to determine if additional contact information is available. ATSDR regional staff will continue to acquire contact information and conduct outreach, including distribution through U.S. mail service of this health consultation, to inform residents of contaminants that are of health concern in their drinking water. ATSDR recommends that local and state environmental and public health agencies continue to inform residents with drinking water wells of the importance of regular water testing, and the responsibilities of all stakeholders (local government, industry, regulators, residents) involved in these types of incidents. *Planning and Preparedness*: ATSDR recommends that drillers and state regulators develop site-specific procedures that protect the public from exposure to chemicals injected into open boreholes to recover drill bits and other 'lost' items. **<u>Chemical-Specific Recommendations</u>** *Iron:* Individuals with hemochromatosis, a rare inherited disease, should consult with their health professionals as appropriate to discuss the additional iron in their diet from well water. *Lithium and Sodium:* Residents consuming well water with elevated lithium or sodium should inform their physician of these additional exposures through groundwater. This is especially important for residences with sensitive subpopulations (e.g., patients

	undergoing lithium treatment or under a sodium-reduced diet, infants/children, pregnant women, those with significant renal or cardiovascular disease, etc.). *Lead*: Residents with lead in their drinking water above 15 µg/L (0.015 mg/L), should take immediate steps to eliminate or reduce their exposures to as low as achievable, either through installing lead-specific treatment, or by using an alternative drinking water source. ATSDR staff will continue to try to reach homeowners with lead detections in their well water above the EPA public water action level of 15 µg/L (0.015 mg/L). The following provides general recommendations for exposures to lead: *Reduce lead exposure*: Because no level of lead in children's blood has been proven safe, ATSDR and CDC recommend reducing lead exposure wherever possible. ATSDR recommends that parents or guardians immediately reduce their own and their children's ingestion of lead in their drinking water and from other sources such as flaking or peeling lead paint and dust. See https://www.cdc.gov/nceh/lead/tips.htm for suggestions on reducing exposure to lead paint and dust. *Reduce lead absorption*: To help decrease lead absorption from any swallowed source, eat a nutritious diet including several small meals per day (appropriate for age and growth) rich in iron, calcium, vitamins C & D and zinc from such foods as dairy products, green vegetables, and lean meats. Proper nutrition is particularly important for children and pregnant women. *Water filtration*: ATSDR recommends homeowners use water filtration/treatment explicitly designed to reduce lead concentrations in residential well water supplies with detectable lead concentrations. *Blood lead screening*: Consistent with statewide childhood blood lead screening guidelines, all families are encouraged to discuss blood lead screening for children six years of age and under with their health care provider. This is especially recommended for families whose home drinking water supply has lead detected above 15 µg/L. *Manganese*: The following table provides general recommendations for manganese in drinking water. ***General Public Health Recommendations for Manganese in Drinking Water*** **Manganese Concentration** — **Recommendation** 300 µg/L or less — Routine water well monitoring, including analyses for manganese 300 to 500 µg/L — Infants (birth to 1 year) use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.

	>500 µg/L	Infants and children use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.
	>1,000 µg/L	All age groups use bottled water or appropriate and properly maintained water treatment system with bi-annual water quality monitoring.

Conclusion 4	**Biological contamination was found in a number of the drinking water sources that were tested.**
Basis for Conclusion 4	Thirty-one water sources were positive for the presence of fecal coliform bacteria. Fecal coliform and *E. coli* can cause severe illness following acute exposures. Ingesting fecal coliform bacteria, including E. coli, can result in serious infections with symptoms including, but not limited to, bloody diarrhea, stomach cramps, fever and vomiting.
Next Steps for Conclusion 4	ATSDR recommended that owners and operators of drinking water sources (i.e., wells and springs) that tested positive for the presence of fecal coliform or *E. coli* take immediate steps to eliminate exposures to the contaminated water, including installing treatment. Residents with bacterial contamination should continue to evaluate their wellhead area and take steps to control any nearby sources that may be contributing to the bacterial contamination in their water supply. Owners whose water supply tested positive for the presence of total coliform but not fecal coliform (or *E. coli)* should monitor their well on a regular basis and consider treatment to improve water quality and to reduce the presence of bacteria in their drinking water.
Data Limitations	ATSDR acknowledges several important data limitations in this public health review: There are temporal and spatial data limitations – Due to variability in timing and frequency of sampling, we cannot be certain that we have samples from all impacted water sources from the beginning of the release until groundwater impacts were resolved. We do not have water quality measurements for these same groundwater wells and springs prior to the JKLM release, so we are not sure what contaminants and concentrations routinely exist in the groundwater wells and springs. ATSDR cannot determine whether all JKLM-related contaminant exposures or longer-term groundwater quality issues were fully assessed. The JKLM-related contaminants were detected in samples for a period of less than six months (September 2015 through February 2016). However, it cannot be determined with the data set whether or for how long JKLM-related contaminants caused naturally-occurring chemicals (e.g., metals) to mobilize in the groundwater. It can also not be determined with the available data set whether naturally-occurring contaminants were already present at similar concentrations in these water sources before the JKLM release occurred. Due to samples being collected over limited and varying time frames for each well and spring, ATSDR cannot determine exposure durations or chronic exposure concentrations for all exposure locations. Due to these sampling limitations, some

	contaminant exposure durations were assessed for both chronic (greater than one year) and intermediate (less than one year, more than two weeks) time frames, including aluminum, barium, lead, lithium, manganese, and sodium. Proprietary chemical information was not provided - ATSDR has concluded that exposures to JKLM-injected products (i.e., isopropanol mixture) have occurred (see Conclusion 1); however, ATSDR does not have sufficient information to determine what other chemicals were in the injected mixtures that residents were exposed to. ATSDR also does not know the duration or concentration of exposure to these other chemicals.
For More Information	For further information about this health consultation, please call ATSDR at 1-800-CDC-INFO and ask for information about the "JKLM Coudersport Site." If you have concerns about your health, contact your health care provider.

Background

Natural gas driller, JKLM Energy, LLC (JKLM), lost a drill bit while drilling for natural gas in Coudersport, Potter County, PA. Drillers used a chemical mixture including surfactants (i.e., "F-485," which includes isopropanol) and "rock drill oil 150 (0428)" to recover the drill bit from the ground (PADEP 2015). The chemicals were not authorized for use during that stage of site activities. One breakdown product (i.e., acetone) and several chemicals used by JKLM (e.g., isopropanol, benzene, xylenes, and ethylbenzene) were detected in samples collected from drinking water taps sourced by residential groundwater wells and springs. A test which indicates the presence of surfactants (i.e., methylene blue active substance, or MBAS) was also positively detected in a number of these private drinking water sources (also referred to in this report as residential wells or RWs). On September 30, 2015, the Pennsylvania Department of Environmental Protection (PADEP) issued a notice of violation to JKLM for (1) failure to construct and operate a well in accordance with Pennsylvania's oil and gas code, (2) unpermitted usage of certain additives, and (3) the discharge of polluting substances (PADEP 2015).

Timeline of JKLM Spill and Response

9/18/2015	JKLM injects unapproved chemicals into ground
9/21/2015	PADEP receives initial resident complaints of well impacts
9/21/2015	PADEP and JKLM begin sampling of groundwater sources
9/30/2015	PADEP issues notice of violation to JKLM
10/27/2015 to 12/14/2015	PADEP issues six determination letters to residents stating impacts by JKLM
2/29/2016	ATSDR receives petition to assess environmental health concerns due to JKLM well incident

The Coudersport area is rural, with predominantly agricultural land and forested areas covering rolling hills and valleys in north central Pennsylvania. The Coudersport town center is located three to four miles west southwest of the Reese Hollow 118 well pad. Approximately 2,217 people live within a four-mile radius of the Reese Hollow 118 well pad. The population includes groups potentially more sensitive to environmental contaminant exposures, including 185 children under six years of age, 338 women of childbearing age (15 to 44 years old), and 504 elderly individuals (65 and older) (U.S. Census 2010).

The Reese Hollow 118 well pad is located on the southeastern slope of a forested valley. Burrows Road is located at the bottom of this valley, to the northwest of the Reese Hollow 118 well pad. Both public and private drinking water sources serve the area. PADEP and JKLM conducted sampling of both public and private ground and surface water sources up to 4 miles from the Reese Hollow 118 well pad, including the Coudersport public water source wells, located over 3.5 miles west. The nearest private residence is less than 600 feet from the JKLM Reese Hollow 118 well pad. Public and private source water data were both assessed in this health consultation.

Following the JKLM release, over 100 sources of drinking water in the area surrounding JKLM's Reese Hollow 118 well pad were sampled. This included sampling of residential groundwater wells, public drinking water source groundwater wells, and natural springs used as private and public drinking water sources. Surface waters (i.e., ponds) were also sampled. See Figures 1 and 2 for site layout, the general location of water sampling, and demographic information for the Coudersport area. (Note, only general geographic information is provided for the locations of drinking water sources to protect individual privacy.) A limited number of private drinking water sources were contaminated by chemicals released by JKLM. PADEP issued letters to six homeowners indicating these homeowners' drinking water sources were impacted or were presumed to have been impacted by JKLM activities. PADEP worked with JKLM to ensure drinking water was provided to these homeowners until the groundwater supply was determined to no longer be contaminated with JKLM-injected chemicals. The PADEP considered the groundwater sources to no longer be impacted when contaminant concentrations were below PADEP's levels of health/potability concern for multiple sampling events over time, or the water was restored to its original state of groundwater quality. Well monitoring continued for approximately six months (September 2015 through February 2016), at which time PADEP determined all wells were restored and monitoring was concluded.

PADEP notified well owners if they had detections of site-related contaminants or other chemicals (e.g., lead) in their well that exceeded public water supply *regulatory* levels (maximum contaminant levels, MCLs, or action levels). Sampling of private wells and other water sources began within days of the September 2015 incident. Sampling continued at varying intervals through the end of February 2016. Contaminated wells and other water sources were sampled at a higher frequency and over a longer period than wells that were determined by PADEP to not have been impacted by JKLM activities. Some residents refused follow up rounds of sampling by the PADEP. Appendix B, Section 3, provides further discussion of ATSDR's assessment of exposure durations.

Statement of Issues

In February 2016, both the Pennsylvania Department of Health (PADOH) and Agency for Toxic Substances and Disease Registry (ATSDR) received requests for public health assistance related to the JKLM incident. PADOH issued a letter to one nearby well owner that was not impacted. The well owner had requested assistance from the state agencies (both PADOH and PADEP) and the sampling data reviewed by the State resulted in the PADOH letter to the property owner summarizing the PADEP determination. Other requests for assistance to the state regarding the JKLM release have been handled by the PADEP Eastern Region Oil and Gas Office. ATSDR determined that the February 2016 citizen's request for assessing public health impacts from the JKLM event met the criteria for accepting a citizen's petition under ATSDR's petition authorities under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund). This report provides ATSDR's public health evaluation of the available public and private drinking water source data related to the September 2015 JKLM event.

Chemicals Detected

Residences near the JKLM Reese Hollow 118 well pad use private wells or springs for drinking water and household uses. The Borough of Coudersport (public wells #81 and #82 or CWTP 1E and CWTP 2, respectively) and the Charles Cole Memorial Hospital (wells #84, #85, #86, and #91) also use groundwater as their drinking water source. Private and public source water wells, along with several surface water sources, were assessed by JKLM and the PADEP for impacts caused by JKLM activities at the Reese Hollow 118 well pad.

1. Private Water Wells. Chemicals related to the JKLM event (isopropanol, acetone, benzene, toluene, ethylbenzene, xylenes, trimethylbenzenes), naturally occurring metals and salts (sodium, manganese, iron, etc.), surfactants and other organic and inorganic compounds were detected in private groundwater wells, some of which exceeded health-based screening values.

2. Public Water Source Wells. Organic compounds (acetone, bis(2-ethylhexyl) phthalate, 1,1-dichloroethane, 2-hexanone, styrene), petroleum-related compounds (benzene, toluene, xylenes, ethylbenzene), naturally occurring metals and salts, and surfactants (by MBAS test) were detected in public water source wells (*public water samples assessed in this document were collected from source wells not from post-treatment locations*).

Chemicals detected in drinking water sources include:

- Isopropanol, benzene, ethylbenzene, and xylenes (JKLM-injected chemicals)
- Acetone (isopropanol breakdown product)
- Aluminum, arsenic, barium, bromide, iron, lead, lithium, manganese, sodium, (naturally occurring or may be related to household plumbing)
- Organic compounds, including polycyclic aromatic hydrocarbons (PAHs) and surfactants (unknown source)

A number of private drinking water wells were also positive for total coliform and/or *E. coli* (bacteria which can cause illness) and surfactants as determined by a methylene blue active substance (MBAS) test. MBAS is a qualitative test that identifies the presence of surfactants. MBAS detections may be attributable to many activities or products, such as household laundry detergent, or natural gas industry activities. Contaminant concentrations diminished over time in groundwater samples. By March 2016, sampling by JKLM and PADEP was completed and well water impacts related to the JKLM incident were no longer detected.

During the initial ATSDR screening process, the maximum analyte/chemical concentration from the available environmental data were compared to health-based screening values (see Appendix A for full screening table). Over 100 water sources (wells, springs, creeks, ponds) were sampled for JKLM-related contaminants (e.g., isopropanol, acetone, benzene, ethylbenzene, xylenes, and surfactants by MBAS). A subset of the groundwater sources (springs and wells) were sampled for JKLM-related contaminants and a broader range of drinking water quality analyses (i.e., target volatile and semi-volatile organic compounds, major ions, metals and salts, bacteria, and general water quality parameters). Chemicals were identified as chemicals of potential concern (COPCs) if the maximum concentration exceeded its respective screening value for the specific exposure duration identified.[1] If an acute or intermediate screening value was not available for screening against acute or intermediate exposure contaminants, the chronic screening value was used for determining whether the contaminant is of potential health concern (COPC) (See Table 1). COPCs require further analyses to determine their public health significance. Contaminant exposures, including bacterial contaminant exposures, and health implications of exposures, are discussed in more detail below.

1 Acute duration exposures are defined as daily exposures up to 14 days. Intermediate duration exposures are defined as daily exposures for more than two weeks and less than one year. Chronic duration exposure is more than 364 days.

Further description of the Coudersport exposure scenario for COPCs are provided in Appendix B. Appendix B also provides further information about the ATSDR health assessment and exposure pathway evaluation process.

Table 1
Drinking Water Contaminants of Potential Concern

Contaminant	**Maximum concentration (in µg/L)**	**Maximum 95UCL (n) (in µg/L)**	**Screening Value (in µg/L)**	**Screening Value Source**	**Estimated maximum exposure dose (RME) in mg/kg/day**	**ATSDR MRL mg/kg/day (duration)**
Acetone	19,400	194 (4)	6,300	ATSDR child RMEG	**0.028**	2 (inter)
Aluminum	43,700	3,420 (25)	7,000	ATSDR child iEMEG	**6.2**	1 (inter)
Barium	1,590	*NC*	1,400	ATSDR child iEMEG	**0.21**	0.2 (inter)
Benzene	7.65	*NC*	3.5	ATSDR child cEMEG	**0.0011**	0.0005 (chron)
Bromide	13,000	12,828 (3)	2,000	WHO cADI	1.8	*NA*
Iron	61,600^	6,200 (30)	1,400	EPA RSL (HI=0.1)	0.88	*NA*
Isopropanol	15,000	1.23 (37)	410	EPA RSL (HI=1.0)	0.00018	2.0 (inter)
Lead	373	*NC*	15	EPA Action Level	*NC*	*NA*
Lithium	110	*NC*	40	EPA RSL (HI=1.0)	*NC*	*NA*
Manganese	2,580	563 (2)	300	EPA Health Advisory	**0.37**	0.05 (chron)
Sodium	146,000	129,255 (19)	20,000	EPA DWEL	*NC*	*NA*
*E. Coli**	*201*	*NC*	*0 (fecal)*	EPA MCL	*NC*	*NA*
*Total Coliform**	*802*	*NC*	*2 (total)*	EPA MCL	*NC*	*NA*

Notes: all concentrations in micrograms per liter (µg/L), except E. coli and coliform; ^ = one time detection, all others in well less than screening value; * - in MPN/100 ml; n - number of samples analyzed for contaminant; RMEG - media evaluation guideline based on EPA reference dose; aEMEG - acute-duration environmental media evaluation guideline; iEMEG - intermediate-duration environmental media evaluation guideline; cEMEG - chronic-duration environmental media evaluation guideline; CREG - cancer risk evaluation guideline (10E-6 value); WHO - World Health Organization; ADI - Acceptable daily intake; RSL - EPA regional screening level; HI - hazard index; MCLG - EPA maximum contaminant level goal; DWEL - EPA Drinking water equivalent level; MCL - EPA maximum contaminant level; RME - reasonable maximum exposure dose; inter - intermediate duration; cADI - children's acceptable daily intake; NA - Not available; NC - Not calculated

It is important to also note that contaminants not specifically related to the JKLM release were identified in drinking water sources. These contaminant exposures are also discussed in this document.

Exposure Pathways Evaluation

ATSDR evaluates whether people may have come into contact with chemicals from a site by examining *exposure pathways*. For more discussion on how ATSDR conducts an exposure pathway assessment, see Appendix B.

ATSDR has concluded that a completed exposure pathway was present at this site from the Reese Hollow 118 well pad to drinking water wells where residents access groundwater for consumption and household use. The release began in September 2015, which is when exposures began in the community. Exposures were mitigated within a few days for well owners with confirmed JKLM-related contaminants. These residents were provided bottled water under an order from PADEP to JKLM after the contamination was detected. Sampling of groundwater sources and surface water continued until late in February 2016, when final rounds of groundwater sampling were completed. At that time, PADEP confirmed that JKLM-related chemicals were no longer being detected in water samples in the area.

A few residents may have been exposed for a brief period (between a few days and several weeks) to JKLM-related contaminants by drinking impacted groundwater from residential wells or by inhaling volatile organic chemicals (e.g., isopropanol) that can be released from well water during household use.

Based on ATSDR's evaluation of exposure durations, which shows exposures to JKLM-related chemicals (isopropanol, benzene, ethylbenzene, and xylenes and acetone) lasted from a few days to a few weeks before mitigation actions were implemented (e.g., bottled water provisions), ATSDR used acute- and intermediate-exposure duration health-based screening values. In the absence of an acute or intermediate screening value, ATSDR used chronic exposure screening values as the basis for screening the environmental data.

This document focuses on ATSDR's public health assessment of exposures to groundwater following the JKLM Reese Hollow 118 well pad event. ATSDR also recognizes that dermal (i.e., skin contact) and inhalation exposures to contaminants are possible, especially during showering and bathing, or other activities where significant quantities of groundwater are in use (e.g., laundering clothes). However, the primary exposure pathway of concern is ingestion of contaminants, and this is the focus of the health implications discussion in this document. When additional exposure pathways are relevant to the specific chemical being assessed, such as for isopropanol, they are evaluated in the health implications discussion section.

ATSDR also evaluated environmental data provided for the same wells that were not specifically related to the JKLM release. Some of these contaminants are naturally occurring substances. For these non-JKLM related contaminants (e.g., sodium, manganese), ATSDR assumed exposures may have been long-term (i.e., greater than one year). This approach to exposure assessment is conservative and assumes, in the absence of comprehensive data, that exposures are chronic or for a full lifetime of up to 78 years, although actual exposures may have been for a shorter time period. These data were evaluated with chronic-exposure screening values.

It is important to note that a completed exposure pathway does not necessarily mean that harmful health effects will occur. A chemical's ability to harm health depends on many factors, including how much of the chemical is present, how long and how often a person is exposed to the chemical, and how toxic the chemical is. Further evaluation of specific chemical exposures is needed to determine whether the exposure could cause harmful effects.

Discussion

This section provides an evaluation of the public health implications of exposures to the chemicals of potential concern. ATSDR assessed the data and determined that exposures to a number of the detected chemicals were of short, limited durations (i.e., less than two weeks to less than six months). These chemicals include isopropanol, acetone, benzene, ethylbenzene, xylenes, aluminum, and barium. Aluminum and barium are not considered site related chemicals; however, temporary water quality changes (e.g. pH, corrosivity) due to the addition of chemicals in the aquifer, such as isopropanol and other surfactants, may lead to increased mobilization of naturally occurring metals and salts. Assessment of these chemicals is based on intermediate duration exposures, as indicated by the data. For other chemicals and analytes detected, the data either indicates chronic exposures are occurring or there is insufficient data to determine whether exposures are of acute (less than two weeks), intermediate (two weeks to less than a year), or long-term (i.e., greater than one year) exposure duration. Assessment of these chemicals are based on chronic exposures using chronic-exposure screening values. See Table 1 for a summary of ATSDR's screening of the sampling data.

Eleven chemicals exceeded screening values:

- Acetone
- Aluminum
- Barium
- Benzene
- Bromide
- Iron
- Isopropanol
- Lead
- Lithium
- Manganese
- Sodium

Finally, it is important to note that a number of residential wells tested positive for the presence of *bacteria* (i.e., total coliform) and some of those wells also tested positive for fecal coliforms or *E. coli*, bacterial contaminants associated with acute health effects from ingestion.

Health Implications from Exposures to Contaminants of Potential Concern

This section provides exposure evaluations for each contaminant of potential concern (COPC). More general information for each of the contaminants of concern is provided in Appendix C.

Acetone Exposure Evaluation

Acetone was detected in 12 drinking water samples. Only one water sample had a detection above its health-based screening value. The maximum acetone concentration of 19,400 µg/L (19.4 mg/L) was detected in the raw water (pre-filtration) from residential well #1 (RW #1), on September 18, 2015. This well has a treatment/ filtration system. The post-filtration sample, collected on the same day (September 18, 2015) had an acetone concentration of 230 µg/L (0.230 mg/L). Acetone exposure concentrations (by ingestion) were below health-based screening values in each of the additional sampling rounds. Based on this data set, ATSDR assumes acetone ingestion from consuming this well water is of intermediate exposure duration (based on the data, exposures were significantly less than one year of exposure, but may have been more than two weeks). Due to effective filtration of RW #1, acetone exposures to the maximum well water concentration of 19,400 µg/L is not expected to have occurred. Consuming water on this date (9/18/15) would have exposed residents to acetone at

Acetone Detection History

Residential Well #1

Pre-drill sampling	Not collected
9/18/15 pre-treatment	**19,400* µg/L**
9/18/15 post-treatment	230 µg/L
10/1/15	42 µg/L
10/3/15	111 µg/L
1/21/16 pre-treatment	<5 µg/L
1/21/16 post-treatment	5.6 µg/L
95UCL	**194 µg/L**

*Note: *=not used to calculate 95UCL; ATSDR health-based screening value is 14,000 µg/L for children.*

the post-treatment concentration of 230 μg/L. Based on pre- and post-filtration data (e.g., 9/18/15 data), some breakthrough of and exposures to acetone occurred for RW #1 users, but these exposures were below the ATSDR health-based screening value.

The ATSDR intermediate-duration minimal risk level (iMRL[2]) for ingestion exposures to acetone is 2 mg/kg/day, which is derived from a 13-week rat study which found no observed adverse effects (NOAEL) at 200 mg/kg/day and a lowest observed adverse effect level (LOAEL) of 400 mg/kg/day. Converting this information to a water concentration using the most sensitive receptor (young child) results in an iEMEG screening value of 14,000 μg/L. Assuming intermediate duration (i.e., less than one year) exposure to acetone at the 95UCL[3] concentration of 194 μg/L (which includes only post-filtration acetone concentrations), the estimated reasonable maximum exposure (RME) dose (0.028 mg/kg/day) is below the iMRL (2 mg/kg/day). Based on sampling information, acetone exposures at this home were mitigated by an effective water treatment system and below levels of public health concern. Acetone has not been classified as a carcinogen by the EPA or the International Agency for Research on cancer (IARC).

Of toxicological significance, this acetone exposure occurred simultaneously with isopropanol exposures (15,000 μg/L) at this home, increasing the potential for adverse health effects from these two chemicals. This concurrent exposure (i.e., acetone and isopropanol) is discussed in the isopropanol exposure evaluation section.

Health effects from ingestion (i.e., drinking and eating with contaminated water) are not expected for children or adults exposed to acetone at the levels and durations observed in Coudersport drinking water wells.

Aluminum Exposure Evaluation

One well (RW #2) had a maximum concentration of 43,700 μg/L (43.7 mg/L), exceeding its respective health-based screening value, the iEMEG, of 7,000 μg/L (7 mg/L) for children. All other wells had aluminum concentrations below the health-based screening value (i.e., iEMEG).

Aluminum was "non-detect" (i.e., it was less than 50 μg/L or 0.05 mg/L) in the pre-drill sample collected from RW #2 on April 22, 2015. The second highest concentration in RW #2, at 386 μg/L (0.386 mg/L), was below the health-based screening value, but above the EPA SMCL of 50-200 μg/L (0.05 to 0.2 mg/L). Over the course of sampling RW #2 from September 21, 2015 through February 24, 2016, twenty-five sampling events resulted in twenty-nine (29) discreet water samples analyzed for aluminum, including samples collected

---

2 An ATSDR MRL is the minimal risk level. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure.

3 The 95UCL is a calculated value that equals or exceeds an exposure unit's actual arithmetic mean of site concentrations 95 percent of the time. For a given number of discrete environmental samples in an exposure unit, the calculated arithmetic mean may be lower or higher than the actual arithmetic mean. However, it is highly unlikely (i.e., no more than 5 percent probability) that the 95UCL will be lower than the exposure unit's actual arithmetic mean. As the number of environmental samples in an exposure unit increases, the difference between the 95UCL and the sample arithmetic mean decreases. The 95UCL should not be confused with the 95th percentile.

on four occasions before and after a treatment system on the water supply. Aluminum was not detected in drinking water on 22 of the 25 sampling events (i.e., it was less than the method detection limit of 0.05 mg/L twenty-two times). The maximum 95UCL of 5,227 µg/L (5.23 mg/L), which assumes exposures to post-treatment water, was calculated from 25 sampling rounds over five months of sampling. The 95UCL (5.23 mg/L) was below the aluminum iEMEG (7 mg/L). To calculate the 95UCL, reported non-detect values were quantified at 0.0325 mg/L by the following formula: the laboratory limit of detection (0.0459 mg/L) divided by the square root of 2 (i.e., 1.4142). Aluminum is not classified as a carcinogen; therefore, cancer health effects are not expected.

Health effects are not expected for children or adults exposed to aluminum by ingestion at the levels detected in Coudersport drinking water wells assessed.

Barium Exposure Evaluation

The maximum barium concentrations of 1,590 and 1,450 µg/L (1.59 and 1.45 mg/L) were detected in two residential wells (RWs #4 and #5, respectively); however, only one round of sampling was conducted at these locations. It is not known what the barium exposure concentration would be in these wells over time due to the limited environmental data for both of these residential wells. Therefore, ATSDR assumes the detected concentrations of barium are present continuously and that chronic exposures to these concentrations of barium are occurring at these residences. The ATSDR child chronic exposure value for barium (cEMEG) is the same as the intermediate value of 1,400 µg/L (1.4 mg/L). The adult cEMEG was not exceeded. Barium levels in all other tested Coudersport drinking water supplies were below health-based screening values.

The majority of research evaluating the health effects of barium is from oral exposure studies and includes numerous case reports and epidemiologic investigations of humans exposed to barium through accidental or intentional ingestion (ATSDR 2007). Other information on the health effects associated with exposure to barium was obtained from various animal studies involving acute, intermediate, or chronic exposure to barium either by gavage or by drinking water.

ATSDR has derived a *chronic-duration* oral MRL of 0.2 mg/kg/day for barium. The chronic MRL is based on a benchmark dose 95% lower confidence level (BMDL05) of 61 mg/kg/day for nephropathy in male mice and an uncertainty factor of 100 (10 to account for animal to human extrapolation and 10 for human variability) and modifying factor of 3 to account for the lack of an adequate developmental toxicity study. EPA used the same study to derive an oral reference dose (RfD) for barium of 0.2 mg/kg/day, based on a benchmark dose level of 63 mg/kg/day for nephropathy in male mice and an uncertainty factor of 300 (10 to account for animal to human extrapolation, 10 for human variability, and 3 for database deficiencies, particularly the lack of a two-generation reproductive toxicity study and an adequate investigation of developmental toxicity) (EPA 2005, NTP 1994).

For adults, the estimated exposure doses do not exceed the chronic MRL or RfD. For a 10-kg and 16-kg child exposed to the maximum barium concentration detected (1,590 µg/L or 1.59 mg/L) and drinking 2 liters of water per day, the estimated exposure doses (0.318 and 0.199

mg/kg/day, respectively) exceed or are close to the chronic MRL and RfD of 0.2 mg/kg/day. Further evaluation, as described below, indicates that these barium exposures are not at levels where children are expected to experience health effects.

Further barium exposure evaluation indicates that children's exposure doses in Coudersport do not exceed the adjusted dose where health effects might be expected to occur (i.e., the MRL which incorporates a benchmark dose and relevant uncertainty factors). The MRL contains an uncertainty factor of 3 applied for database uncertainty because adequate developmental studies have not been conducted. These developmental studies would apply to adults exposed during pregnancy and do not apply to children's exposures. Adult doses did not exceed the MRL, which contains this uncertainty factor. Barium is not classified as carcinogenic via the ingestion route.

Health effects are not expected from ingestion exposures to barium, either for children or adults, at the levels detected in Coudersport groundwater.

Benzene Exposure Evaluation

The maximum benzene concentration of 7.65 µg/L (0.00765 mg/L) was detected by JKLM sampling on September 21, 2015 in RW#2. This result exceeded the EPA maximum contaminant level (MCL) for benzene (5 µg/L) in public water supplies. Split sampling of this well by PADEP at the same time found a benzene concentration of 3.02 µg/L (0.00302 mg/L). The RW#2 benzene detection by JKLM sampling was above the ATSDR child *chronic* EMEG (3.5 µg/L), but below the adult screening value of 13 µg/L. This detection also exceeded the ATSDR CREG of 0.44 µg/L. ATSDR chronic health-based screening values (cEMEG and CREG) are based on a lifetime of daily exposures to the contaminant. Benzene was not detected in subsequent sampling of this well on October 1, 2015, or thereafter, indicating exposure to benzene was of a short, and not a chronic duration. Due to bottled water provisions implemented by PADEP order, the actual benzene exposure duration may have been less than one week. Benzene was not detected in other drinking water sources, but was detected in one pond sample at 1 µg/L (0.00098 mg/L).

Benzene is a widely used chemical and can be released from many sources, including as a by-product from combustion of coal, oil, gasoline, and other fuels. Drinking water with high levels of benzene over a long period of time can cause alterations to the blood such as a decrease in red blood cells (pancytopenia), impairment to the immune system and certain cancers such as leukemia (ATSDR 2007). The benzene concentration in RW#2 and estimated exposure duration for residents using this water supply was significantly lower than those shown to cause adverse health effects identified above. The toxicological literature on low concentration, short term benzene exposures by ingestion, is limited (ATSDR 2007b). The lowest NOAEL identified in the toxicology literature (50 mg/kg/day for female rats, ATSDR 2007b) is higher than the estimated acute exposure dose (0.0011 mg/kg/day) from drinking RW#2 water. The LOAEL (250 mg/kg/day) from the same study identified decreased food consumption as a less serious health effect. The lowest LOAEL of 88 mg/kg/day was identified in a one-day ingestion study on rats (ATSDR 2007b). This study by Cornish and Ryan (1965) found that rats exposed to benzene at a dose of 88 mg/kg/day exhibited slight central nervous system (CNS) depression following exposure (ATSDR 2007b). The LOAEL for CNS depression (88 mg/kg/day) is higher than the estimated acute exposure dose (0.0011 mg/kg/day) from drinking RW#2 water. The benzene concentration in RW#2 and estimated exposure duration for residents using this water supply was significantly lower than those shown to cause adverse health effects identified above.

The EPA one-day and 10-day benzene health advisory value for drinking water is 200 µg/L (EPA 2012). A health advisory is a non-regulatory drinking water contaminant concentration at which adverse health effects would not be anticipated to occur over specific exposure durations. Health advisories are provided by the EPA to assist state, federal and local agencies responsible for protecting public health when emergency spills or contamination situations occur (EPA 2012). Benzene exposure from drinking water from RW#2 is below the EPA 10-day health advisory. Benzene is a known human carcinogen, but based on the short duration exposure in this situation, ATSDR did not evaluate the potential for additional cancer risk over a lifetime of exposure.

Health effects are not expected from benzene ingestion exposures at the levels detected in Coudersport groundwater.

Bromide Exposure Evaluation

The maximum bromide concentration of 13,000 µg/L (13 mg/L) was detected on September 21, 2015 from residential well RW #2, approximately three days after JKLM injected chemicals at the Reese Hollow 118 well pad. Bromide was not detected at any other time in this well (i.e., pre-drill sample collected in April 2015 was non-detect at less than 50 µg/L and October 14, 2015 sample was non-detect at less than 214 µg/L), suggesting bromide exposures from this well are of short duration. Based on this limited environmental data, the longest duration of bromide exposures to RW #2 water are less than six months (the period between pre-drill sampling in April and non-detect sample collected in October). The estimated average concentration from the three rounds of sampling was 4,396 µg/L. The available well water data are not sufficient to calculate a 95UCL. Residential well #2, due to the maximum detection of 13,000 µg/L, represents the worst-case Coudersport bromide exposure scenario.

Health effects from ingestion of inorganic bromide in drinking water was originally evaluated by the Joint Food and Agriculture Organization of the United Nation (FAO)/WHO Meeting on Pesticide Residues in 1966, which recommended an acceptable daily intake (ADI) for humans of 0 - 1 mg/kg body weight, based on a minimum pharmacologically effective dosage in humans of about 900 mg of potassium bromide, equivalent to 600 mg of bromide ion (WHO 2010). This acceptable daily intake (ADI) of 0 - 1 mg/kg body weight was reaffirmed with new data in 1988 and in a subsequent second human study (WHO 2010).

A conservative no observed adverse effect level (NOAEL) of 4 mg/kg body weight per day (for marginal effect within normal limits of electroencephalogram [EEG] in females at 9 mg/kg body weight per day) suggests an ADI of 400 µg/kg body weight, including an uncertainty factor of 10 for population diversity (WHO 2010). An ADI of 400 µg/kg body weight yields an acceptable total daily intake of 28,000 µg/day for a 70-kg person, 4,000 µg/day for a 10-kg child, and 6,400 µg/day for a 16-kg child.

Assuming a relative source contribution of 50% from drinking water (the other 50% from food, consumer products, etc.), the maximum drinking water concentration before exceeding the ADI value, the ADI_{DW}, for a 10-kg child consuming 1 liter/day would be up to 2,000 µg/L; for a 16-kg child consuming 1 liter/day, the value would be up to 3,200 µg/L; and for a 70-kg adult consuming 2 liters/day, the ADI_{DW} would be 7,000 µg/L. Drinking water exposure to bromide using the RW #2 average concentration of 4,396 µg/L exceeds the suggested ADI_{DW} for children consuming one liter of well water (4,396 µg/day) and adults consuming two liters of water (8,792 µg/day). Exposures to bromide from residential wells RW#40 (3,260 µg/L) and RW#42 (3,370 µg/L) would have exceeded the ADI_{DW} for children, but not adults. Assuming 50% relative source contribution of bromide from drinking water, the total estimated daily intake of bromide for children consuming water from RWs #2, #40 and #42, exceeded the WHO ADI, but is below the conservative NOAEL of 4 mg/kg/day.

There is uncertainty regarding the potential for health effects from brief exposures to bromide at levels slightly above the recommended ADI. There is insufficient animal or human study information to determine the carcinogenic risk from exposure to bromide. There is uncertainty regarding the potential for adverse health effects following brief exposures to bromide at levels above the FAO/WHO ADI of 0.4 mg/kg/day but well below the conservative NOAEL of 4 mg/kg/day. Large doses of bromide cause nausea and vomiting, abdominal pain, coma and paralysis. The exposure concentrations observed in Coudersport slightly exceed acceptable daily exposure levels (ADI) and health effects may or may not have occurred following exposures.

ATSDR concludes that it is possible that some individuals may have experienced health effects from exposures to bromide over a brief time period in 2015 (wells RW#2, #40, and #42); however, this conclusion is highly uncertain due to limitations in the toxicology literature.

Iron Exposure Evaluation

Iron concentrations in twelve wells exceeded the EPA RSL. Iron levels above the SMCL may cause water to have a bad taste and have a rusty color. This rusty color may stain clothes and dishes. This water may be unsuitable for drinking and cooking.

Iron is a required nutrient, and levels in residential well water are typically under 300 µg/L (WHO 1996). The recommended adequate intakes (AI) for iron are: 8 milligrams per day (mg/day) for men and post-menopausal women, 18 mg/day for pre-menopausal women, 10 mg/day for adolescents and 27 mg/day for pregnant women. The upper acceptable daily intake (UL) is 45 mg/day (IOM 2001).

Drinking water from the Coudersport residential well with the highest level of iron (one-time detection of RW#2 at 61,600 µg/L) would add approximately 61 and 123 mg of iron to a child (1 liter of water/day) and an adult's daily diet (2 liters of water/day), respectively. These increased intakes of iron add a significant quantity of iron to an individual's diet, exceeding the UL from water ingestion alone (excluding food intake, the primary source of iron in a daily diet). However, the maximum concentration was significantly higher than the next highest detected level (750 µg/L or 0.75 mg/L), suggesting a short duration of exposure to elevated iron. To assess iron exposures, the 95UCL from 30 sampling rounds of this water source was determined to be 6,200 µg/L (6.2 mg/L). Exposures to iron at the 95UCL would result in daily intakes that are below the UL, indicating exposures to iron from this well are not of public health concern. The next highest iron level detected in Coudersport groundwater was 8,690 µg/L (8.69 mg/L). Ingesting iron at this second highest concentration or from all other wells sampled in Coudersport during the investigation would result in daily iron intakes below the UL. Iron is not classified as carcinogenic.

Ingestion exposures to the iron in Coudersport water wells are not likely to result in adverse health effects in healthy adults and children.

It should be noted that a rare inherited genetic disease called *hemochromatosis* is associated with iron overload in a small percentage of persons**.** This disorder may not manifest until adulthood. Therefore, early consultation is recommended for families aware of their potential susceptibility because of relatives who have been told they have the disease. **If any individuals with elevated iron in their well water are on reduced-iron diets to treat this condition, these individuals should consult their health professionals to discuss the additional iron exposures from consuming their well water.**

Isopropanol Exposure Evaluation

Isopropanol was detected three times - once each in three wells (RW#1 at 15,000 µg/L or 15 mg/L; RW#2 at 175 µg/L or 0.175 mg/L; and, RW#42 at 101 µg/L or 0.101 mg/L); subsequent sampling events were non-detect for isopropanol. The EPA regional screening level (RSL) for isopropanol in drinking water is 410 µg/L; a value which accounts for each of three possible exposure routes (ingestion, dermal and inhalation). Following the injection of isopropanol into the ground at the Reese Hollow 118 well pad, each of the three wells (RW#1, #2, and #42) were sampled more than 35 times for the contaminant. Of toxicological significance is concurrent exposure to isopropanol and acetone. One residential well, RW#1, was contaminated with both isopropanol and acetone, and exposures to these chemicals occurred simultaneously, increasing the potential for adverse health effects from these exposures. This concurrent exposure is discussed in more detail below.

Isopropanol is a volatile organic compound (VOC) that readily “offgases” from water, resulting in inhalation exposures when contaminated water is used. Irritation of the mucous membranes of the upper respiratory tract may occur following inhalation of isopropanol. Skin contact has also been shown to produce irritating effects on the skin, but exposure durations and chemical concentrations need to be high enough to produce these irritant effects. The isopropanol screening value for dermal exposures (EPA RSL of 6,500,000 µg/L) was not exceeded in any well and is not further evaluated in this document. This isopropanol exposure evaluation focuses on the potential health implications of acute- and intermediate-duration isopropanol ingestion and inhalation exposures from home well RW#1, the only well exceeding screening values. Isopropanol at the levels detected in RW#2 and RW#42 well water is not of public health concern from any route of exposure (inhalation, dermal, ingestion) and adverse health effects from isopropanol exposures at these homes are not expected.

If exposure concentrations exceed health-based screening levels and exposures occur for sufficient durations, concurrent isopropanol and acetone exposures may result in adverse health effects. Acetone is the primary metabolite produced in the body following exposure to isopropanol. Acetone exposure concentrations are therefore increased when an individual is exposed to both of these chemicals in the environment. Clewell et al. (2001), Gentry et al. (2002, 2003), and Clark et al. (2004) used computation toxicology to evaluate the health effects of acetone and isopropanol following inhalation or ingestion route isopropanol exposures. Based on these evaluations, isopropanol and acetone appear to each contribute to central nervous system (CNS) effects following isopropanol exposure.

However, exposures to isopropanol and acetone together or singly were not seen at levels expected to produce health effects with the exception of the maximum level detected in RW#1. As noted in the acetone exposure evaluation section, acetone exposures concentrations evaluated singly were low and did not exceed health-based screening levels. The maximum concurrent (with isopropanol) acetone exposure concentration of 230 µg/L was below health-based screening levels. Acetone exposures concurrent with isopropanol were less than 6 months (acute or intermediate duration), primarily occurring through inhalation during bathroom shower and other household water use, and the toxicological significance of this combined exposures is not expected to be significantly different than from the isopropanol exposure dose alone.

Ingestion Exposure Route

The U.S. EPA sub-chronic (less than one year) and chronic (greater than a year and up to a lifetime) exposure provisional reference dose (p-RfD) is 2 milligrams of isopropanol per kilogram of body weight per day (2.0 mg/kg/day). The p-RfD was derived from a toxicology study on rabbits that found decreased fetal weight (developmental effects) as the critical health effect. For residential well RW#1, the estimated central tendency of isopropanol ingestion exposure (CTE) and the reasonable maximum exposure (RME) levels range from 0.16 to 2.1 mg/kg/day. All estimated exposures fall below the p-RfD, with the exception of the RME for small children/infants. This scenario for small children, provided in the formula box below, results in a daily exposure dose of 2.1 mg/kg/day, which exceeds the RfD of 2.0 mg/kg/day. However, the critical health effect for which the p-RfD is derived is a developmental effect (decreased fetal birth weight) and is not relevant for infants (the exposed subpopulation) whose sub-chronic dose exceeded the p-RfD. It is important to note in this section that bottled water was provided to the residents who use water from well RW#1 as soon as contamination was identified. Providing alternate water is likely to have limited the ingestion exposure durations to no more than a few days. Also, the odor from isopropanol contamination in the water is likely to have provided a warning of the chemical's presence, and this may have acted to reduce the volume of contaminated water consumed before alternative water was provided.

Based on this evaluation, ATSDR concludes that isopropanol *ingestion* exposures alone that occurred in Coudersport are not expected to have resulted in adverse health effects.

Inhalation Exposure Route

Isopropanol exposures through inhalation are of particular concern when drinking water is contaminated, as this exposure is added to ingestion and dermal exposures resulting in a higher

Calculating the Reasonable Maximum Exposure (RME) for Isopropanol Ingestion Exposures for Small Child	
D	= (C × IR × EF) / BW
Exposure dose (D)	= (contaminant concentration x water intake rate x exposure factor)/ BW
2.1 mg/kg/day	= (15 mg/L x 1.113 L/day x 1)/7.8 kg
D = Exposure Dose (mg/kg/day), **C** = Contaminant Concentration (mg/L), **IR** = Intake Rate (L/day), **EF** = Exposure Factor (unitless) and equal to 1, **BW** = Body Weight (kg)	

cumulative exposure to the chemical of concern. The EPA reference concentration (RfC), at 200 micrograms per cubic meter (μg/m^3) is a chronic exposure screening value, where exposures at or below that concentration are not expected to result in adverse health effects. Because isopropanol exposures from well RW#1 contamination may have occurred over no more than a few days (there was only one sampling round indicating the presence of isopropanol in this water supply), ATSDR identified an intermediate exposure duration, health-based screening value for comparison to the estimated maximum inhalation exposure concentration in Coudersport (RW#1).

The California Office of Environmental Health Hazard Assessment (OEHHA) has derived a sub-chronic (i.e., intermediate or less than one year) isopropanol inhalation screening value of 3,200 μg/m^3 (OEHHA 2000). OEHHA derived this sub-chronic inhalation screening value from Nelson et al. (1943). In this study, ten human subjects were exposed for 3-5 minutes to 1,000,000 or 2,000,000 μg/m^3 isopropanol (Nelson *et al*., 1943). Exposure to 1,000,000 μg/m^3 isopropanol produced mild irritation of the eyes, nose, and throat. When exposed to 2,000,000 μg/m^3 the majority of the subjects declared the atmosphere unsuitable for a prolonged exposure. The subjects indicated, however, that prolonged exposure to 500,000 μg/m^3 would not be objectionable. Based on this study, a LOAEL of 1,000,000 μg/m^3 was identified. Based on subject's comments from the study, a no observed adverse effect level (NOAEL) of 500,000 μg/m^3 was identified for a 4-minute exposure. To derive the acute screening level of 3,200 μg/m^3, the NOAEL of 500,000 μg/m^3 was used as the point of departure. After extrapolating the Nelson *et al*. (1943) study results (i.e., the NOAEL) from 4 minutes to one hour of exposure time (~32,000 μg/m^3) and by applying an uncertainty factor of 10 for human variability, the one-hour screening value of 3,200 μg/m^3 was identified (OEHHA 2000).

Because isopropanol inhalation exposure in Coudersport was for a duration well below one year, ATSDR calculated a time-weighted average of one hour of exposure to compare to the OEHHA one-hour screening value. ATSDR utilized a "shower model" to identify an inhalation exposure point concentration, or EPC, for comparison to the one-hour OEHHA value (see Appendix D for additional shower model information). This inhalation EPC is based on the concentration detected in well water (15 mg/L) and is calculated for exposures while in the bathroom during showering and for a brief period after showering (total time of 50 minutes). The maximum estimated isopropanol EPC (RME) in the bathroom following a 30-minute shower is 108,000 μg/m^3. The central tendency estimated isopropanol EPC (CTE) in the bathroom following an 8-minute shower is 29,000 μg/m^3.

To compare to the one-hour OEHHA screening value, a time-weighted average (TWA) was calculated for both the RME and CTE exposure scenarios (see Appendix D for calculations). The one-hour TWA estimates for typical (CTE) and worst-case (RME) exposures to isopropanol from well RW#1 are 6,300 (6.3 mg/m^3) and 90,000 µg/m^3 (90 mg/m^3), respectively. Typical and worst-case isopropanol exposure scenarios exceed the OEHHA screening value of 3,200 µg/m^3 (3.2 mg/m^3) and the worst-case exposure scenario exceeds the extrapolated one-hour NOAEL of 32,000 µg/m^3 (32 mg/m^3).

Isopropanol exposure via inhalation at the estimated concentration from one well, RW#1, may result in adverse health effects for some individuals, and particularly children whose exposures at the estimated air concentrations result in higher doses due to lower body weight and higher respiratory rates. Some individuals may be more sensitive to isopropanol exposures, including persons with eye, skin, respiratory or neurological conditions and diabetics.

Adverse health effects from these isopropanol inhalation exposures may include irritation of the mucous membranes of the upper respiratory tract, including eye, nose and throat irritation. These effects are expected to be of short duration with no permanent health effects. When the individual is removed from the exposure, irritant effects are expected to diminish. There is variability in individual responses to an irritant like this chemical. While some individuals may experience these short-term health effects, others may not experience any adverse effects from these isopropanol exposures.

Lead Exposure Evaluation

There is no known safe blood lead level in children. Lead in drinking water at any level should be reduced or removed. Lead in drinking water is of public health concern because of the potential neurological effects on the developing fetus and young children. EPA has established a health-based goal for lead in public drinking water supplies (MCLG) of zero. The EPA action level for lead in public water supplies is 15 µg/L. Fifty-six drinking water sources had detectable lead levels; nineteen drinking water sources had lead above the EPA action level (see Table 2).

Table 2
Maximum Detected Lead Levels (µg/L) in Drinking Water
Coudersport Groundwater Wells (values rounded up to whole numbers)

Well ID#	Total Lead		Well ID#	Total Lead		Well ID#	Total Lead
1	***28***		**37**	***52***		69	4
2	***33***		**38**	***303***		70	4
3	7		40	6		72	4
7	12		**42**	***373***		73	10
8	4		43	7		**75**	***67***
11	5		45	7		**78**	***39***
12	5		46	7		**86**	***212***
13	7		**49**	***218***		89	7
19	4		51	13		90	5

Well ID#	Total Lead		Well ID#	Total Lead		Well ID#	Total Lead
20	***95***		52	***20***		91	5
23	***19***		**56**	***47***		92	4
24	4		58	7		**95**	***54***
26	9		**59**	***144***		**96**	***46***
27	6		61	4		97	4
28	***75***		62	6		98	7
29	***46***		**63**	***73***		105	11
31	11		64	12		108	5
34	4		65	11		Hosp N	5
35	10		66	4			

Notes: µg/L: micrograms per liter; J = Analyte present, reported value is an estimate; **bold** values indicate concentration above U.S. Environmental Protection Agency public drinking water supply action level of 15 µg/L

Health Implications of Lead Exposures

Chronic exposure to low lead levels in children has been shown to cause effects on the central nervous system, which can result in deficits in intelligence, behavior, and school performance. Health effects from lead exposure in children and unborn fetuses include both physical and mental impairments, hearing difficulties, impaired neurological development, and reduced birth weights and gestational age. Some health effects from lead exposure, such as impaired academic performance and motor skills, may become irreversible and persist, even when blood lead levels (BLL) return to below 5 micrograms per deciliter (µg/dL), the current CDC reference value. While there is some discrepancy in the scientific literature between the exact decreases in IQ points associated with a rise in BLL in children, the weight of scientific evidence supports that there is an inverse relationship. It has been hypothesized that the age of exposure is a factor (because younger children are more susceptible to neurological disorders). More research is needed to further delineate the effect of low level lead exposure, particularly on children (CDC 2012). Numerous studies have observed that low lead level exposure during the developmental stages can produce lifelong changes, including (but not limited to):

- **Jusko, *et al.* found children's intellectual functioning at 6 years of age is impaired by blood lead concentrations well below 10 µg/dL (Jusko *et al*. 2008).**
- **A study by Canfield, R.L., *et al*. concluded that IQ declined by 7.4 points as lifetime average BLL concentrations increased from 1 to 10 µg/dL (Canfield *et al*. 2003).**
- **Lanphear, B.R. *et al*. found environmental lead exposure in children who have a BLL <7.5 µg/dL is associated with intellectual deficits (Lanphear *et al.* 2005).**

There is insufficient animal or human study information to determine the carcinogenic risk from exposure to lead. EPA, DHHS and IARC identify lead as possibly carcinogenic or reasonably anticipated to be carcinogenic to humans (ATSDR 2007a). Limited human and less than sufficient animal evidence is listed as the determination for this carcinogenic categorization. There is no conclusive proof that lead causes cancer in humans (ATSDR 2007a).

ATSDR concludes that ingestion of lead from contaminated Coudersport drinking water wells may result in adverse health effects. Children and the developing fetus are especially at risk for adverse health effects from lead ingestion.

ATSDR recommends homeowners take immediate steps to eliminate lead exposures (e.g., install drinking water treatment, address lead paint issues, blood lead testing, etc.), especially if the lead concentration in their water supply exceeds 15 µg/L, the EPA action level.

Lithium Exposure Evaluation

None of the drinking water samples had lithium levels above the ATSDR site-specific acute screening value of 1,500 µg/L. ATSDR has not developed a screening value for chronic lithium exposures. Therefore, ATSDR used the EPA regional screening value (RSL) of 40 µg/L to evaluate chronic lithium exposures. The RSL is based on the EPA 2008 provisional, peer-reviewed toxicology value (PPRTV) for lithium, which identified a provisional reference dose (p-RfD) of 0.002 milligrams per kilogram per day. The RSL value is derived using current EPA exposure assessment inputs (i.e., a child weighing 15 kilograms and a daily ingestion of 0.78 liters of water per day). The PPRTV includes a composite uncertainty factor of 1000 to account for extrapolation from a LOAEL to a NOAEL (factor of 10), to protect susceptible individuals (factor of 10), and to account for database insufficiencies (factor of 10) (EPA 2008).

There is very limited toxicological literature on young children exposed to lithium. The potential for adverse health effects in sensitive subpopulations is uncertain because of the lack of relevant study data. Potentially sensitive populations for lithium exposures include patients undergoing lithium treatment, children, pregnant women, and those with significant renal or cardiovascular disease, or dehydration or sodium depletion with concurrent long-term use of medications such as diuretics (e.g., hydrochlorothiazide), nonsteroidal anti-inflammatory agents (e.g., ibuprofen), calcium channel blocking agents (e.g., verapamil), and angiotensin-converting enzyme inhibitors (e.g., captopril).

Individuals (children or adults) consuming untreated water from any of the seven Coudersport area groundwater wells with lithium concentrations above 40 µg/L would result in exposure doses exceeding the PPRTV. These seven wells include residential wells #17, #32, #61, and #68, and public water wells #81, and #82 (Coudersport water treatment plant wells), and #84 (Charles Cole Memorial Hospital well).

We do not know if lithium can cause cancer in humans. EPA does not classify lithium as a human carcinogen. Lithium is undergoing clinical trials as part of the treatment regime in clinical cancer studies. Additionally, Cohen *et al.* (1998) reported that patients undergoing lithium therapy have lower cancer prevalence than the general population and that lithium may have a protective effect. There is insufficient animal or human study information to determine the carcinogenic risk from exposure to lithium.

ATSDR cannot determine whether exposures to lithium at the levels detected in Coudersport drinking water wells will result in adverse health effects. Any person taking lithium for medical reasons, however, should consult their physician if they are consuming water (i.e., drinking or cooking) from any of the wells with lithium levels above 40 µg/L.

Due to this uncertainty, ATSDR recommends that homeowners with water wells containing lithium levels exceeding 40 µg/L take steps to reduce exposure, such as installing water filtration.

Manganese Exposure Evaluation

Three of the six wells with manganese exceeding the EPA drinking water health advisory (HA) level of 300 µg/L (RWs #34, #35 and #71) were sampled only once for manganese analyses, resulting in uncertainty about the duration of manganese exposures at these residences. For these three wells with only one round of sampling, ATSDR assumed chronic exposures (i.e., daily exposures over a lifetime) to the detected manganese concentrations are occurring (see Chronic Manganese Exposures section below). The additional three of six wells (RWs #38, #2 and #95) had multiple rounds of manganese sampling and analyses. Within one month (i.e., by October 22, 2015) of detecting exceedances of the EPA HA for manganese (i.e., 300 µg/L or 0.3 mg/L) (EPA 2004) in these three wells, the manganese concentrations fell back to levels below 300 µg/L. Based on the available data set, ATSDR assessed both the short term and long-term exposures (i.e., less than one year) to manganese in these wells.

All other wells had manganese results below health-based screening levels. Short- or long-term exposures to drinking water wells with manganese concentrations below the health-based screening level are not expected to result in adverse health effects.

Short-Term Manganese Exposures (RWs #2, 34, #35, #38, #71, and #95)

The EPA short term (10 days or less) health advisory value for manganese in drinking water is 1,000 µg/L (EPA 2004). EPA also recommended using a lower health advisory of 300 µg/L for infants under 6 months, because of the concerns for differences in manganese content in human milk and formula and the possibility of a higher absorption and lower excretion in young infants (EPA 2004). Exposures to the maximum reported manganese levels in RWs #35 (2,580 µg/L) and #2 (1,110 µg/L) exceeded the EPA short-term advisory value of 1,000 µg/L. Children and adults may have experienced health effects following short duration ingestion exposures to manganese in RWs #35 and #2.

Children’s short-term ingestion exposure to the maximum manganese concentrations in RWs #95 (419 µg/L), #71 (415 µg/L), #38 (381 µg/L), and #34 (376 µg/L) exceeded the lower advisory level of 300 µg/L suggested by EPA for short term manganese exposures to children. Children may have experienced health effects following short duration exposures to manganese in RWs #95, #71, #38, and #34.

Chronic Manganese Exposures

ATSDR notes here that conclusions made on the following evaluations are uncertain because there is limited information available regarding exposure durations for a number of wells assessed. For adverse health effects to occur, chronic exposures would need to be of sufficient durations.

Chronic exposures to manganese can be harmful to human health. Manganese exposure at an average concentration of 793 µg/L has been shown to be associated with reduced full-scale performance and verbal raw scores in children in Bangladesh who consumed drinking water with high levels of manganese for 10 years (Wasserman *et al*., 2006). In a more recent study, Wasserman *et al*. (2011) reported that manganese exposures >500 µg/L (mean of 725 µg/L) resulted in lower perceptual reasoning and working memory scores after 8 years or more of exposure.

For this site-specific evaluation, ATSDR used the scientific literature to select a Lowest Observed Adverse Effect Level (LOAEL) of 0.07 mg/kg/day to compare with the estimated exposure doses for manganese in drinking water in the Coudersport site area. In Table 3, we summarize the toxicological studies used to select the mid-range LOAEL of 0.07 mg/kg/day.

The three studies investigating manganese exposure in children with neurological endpoints in Table 3 had estimated LOAELs ranging from 0.06 to 0.08 mg/kg/day. ATSDR selected the mid-range LOAEL from these studies to use in this evaluation. We then used this information to generate a summary table of protective public health recommendations for private well water users to consider (see Table 4). ATSDR calculated exposure doses for several age groups (infants, children, adults) to develop these recommendations using age-specific maximum intake assumptions.

Table 3
Summary of Manganese Drinking Water Studies with Neurological Endpoints Used in the Selection of a Lowest Observed Adverse Effect Level (LOAEL) for Evaluation Purposes (in mg/kg/day)

LOAEL	Reference	Population	Exposure Duration (years)	Endpoint
0.06	Kondakis *et al.* 1989	Adult	50	Neurological
0.06	Woolf *et al.* 2002	Children	5	Neurological
0.07	Wasserman *et al.* 2006	Children	10	Neurological
0.08	Wasserman *et al.* 2011	Children	8+	Neurological

(RWs #2, 95, and 38) – multiple data points per well
To assess chronic exposures, the 95UCL was calculated for each well with sufficient data. Wells RW#2 (167 µg/L) and RW#95 (168 µg/L) had estimated maximum chronic manganese exposures below the EPA HA of 300 µg/L. Well #38 had only two sampling results (381 µg/L and <0.002 µg/L), which is insufficient to calculate a 95UCL that is representative of chronic exposures from this well water. Therefore, the maximum value was used to assess worst-case exposure. The maximum concentration of 381 µg/L only slightly exceeded the EPA HAL of 300 µg/L and the second round of sampling, which occurred approximately three weeks after the maximum detection, showed no manganese detected in the well water. Based on available data, chronic manganese exposures from wells RW#38, #2, and #95, are not expected to result in adverse health effects.

Residential Well #35 (manganese at 2,580 µg/L) – one round of data
Children's exposure doses, assuming one liter of well water is consumed per day, at 0.258 and 0.161 mg/kg/day for 10- and 16-kg children, respectively, are above the LOAEL (0.07 mg/kg/day). Adults drinking 2 liters of water per day would be exposed to approximately 5.2 milligrams (mg) of manganese from drinking this well water alone, resulting in a daily exposure

dose equal to the LOAEL. When adding manganese exposures from food, the daily exposures for adults and children are much higher than the LOAEL. Both chronic and short-term exposures to manganese at the concentration detected in RW #35 may result in adverse neurological health effects for adults and children.

Residential Wells #71 (415 µg/L) and #34 (376 µg/L) – one round of data
Daily exposure doses for children range from 0.02 to 0.04 mg/kg/day, below the LOAEL of 0.07 mg/kg/day. Adult exposure doses from exposure to these wells' water (less than 0.01 mg/kg/day) also falls below the LOAEL. Additional exposures to manganese from foods would increase the daily dose and the risk of health effects. When including exposures to manganese from both food and water from RWs #71 and #34, children's exposure doses approach the LOAEL (0.04 to 0.08 mg/kg/day), and may exceed the LOAEL in some instances, particularly for infants and children under three years of age, who are considered a sensitive population. Excess consumption of well water also increases manganese exposures, whether through directly consuming the water or from its use in formula. Infants and children under three years of age may experience adverse health effects from chronic consumption of water from RWs #71 and #34. Manganese exposures for children older than 3 years of age and adults are not expected to result in adverse health effects.

Based on ATSDR's evaluation of the available sampling information for private wells from this site area, **ATSDR concludes that adverse neurological health effects may occur for infants and children consuming water with manganese greater than 300 µg/L (wells RW#2, #3, #35, #38, #71, and #95). Adverse neurological health effects may occur for adults consuming untreated water from residential well #35; however, one round of data is insufficient to determine an accurate long-term manganese exposure concentration.**

Table 4 summarizes ATSDR's general public health recommendations for manganese in drinking water.

Table 4
General Public Health Recommendations for Manganese in Drinking Water

Manganese Concentration	Recommendation
300 µg/L or less	Routine private water well monitoring, including analyses for manganese.
300 to 500 µg/L	Infants (birth to 1 year) use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.
>500 µg/L	Infants and children use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.
>1,000 µg/L	All age groups use bottled water or appropriate and properly maintained water treatment system with bi-annual water quality monitoring.

Sodium Exposure Evaluation

The Charles Cole Memorial Hospital south supply well (#84) had the highest individual sodium result (146,000 µg/L or 146 mg/L) and 95UCL (129,250 µg/L or 129 mg/L). Consuming *untreated* drinking water with the highest average sodium concentration (#84 at 129 mg/L), would result in an additional 258 mg of sodium per day for an adult and 129 mg per day for a child. This additional sodium ingestion would not result in individuals exceeding the U.S.

Departments of Health and Human Services and Agriculture (HHS/USDA) recommended dietary guideline for general and sensitive populations of 2,300 mg/day from their drinking water consumption alone (USDA 2010), but it is a relevant sodium source in an individual's daily diet. It is important to note that the primary source of sodium intake is food, which is not included in the above daily sodium intake calculations. Consuming untreated water from well #84 would not exceed the UL for sodium of 1,500 mg/day for young children (1-8 years old) or 2,300 mg/day for adults (14+ years old).

Sodium in each of the other Coudersport site area drinking water sources is at lower concentrations than that found in supply well #84. Sodium intake from drinking water in the site area alone is not expected to result in adverse health effects. However, it should be noted that each additional sodium intake adds to the already over-threshold burden for most Americans. Individuals on sodium restricted diets or residences with sensitive subpopulations (e.g., bottle-fed infants) consuming groundwater (i.e., residential wells and springs) with elevated sodium should discuss this additional exposure with their physician.

ATSDR recognizes bottle-fed infants as one particularly sensitive subpopulation for sodium exposures from well water. As stated above, sodium is essential for adequate functioning of human physiology, but our population is affected, in general, by too much rather than too little sodium consumption. The World Health Organization (WHO) also notes that that the requirement for sodium in infants is lower than that for children and adults, and "…high sodium intake may lead to hypernatraemia. This is a problem for bottle-fed infants and is the reason why sodium levels in infant formulae have been reduced significantly over time" (WHO 2007). Sodium is not considered to be carcinogenic.

Sodium intake from drinking water at this site is not expected to result in adverse health effects. However, individuals on sodium restricted diets or individuals with infants should discuss their drinking water sodium results with their physician.

Bacterial Contamination, Coliforms including E. coli

A positive coliform test of private well water means possible contamination and a risk of waterborne disease. A positive test for total coliforms always requires more tests for fecal coliforms or *E. coli*. A confirmed positive test for fecal coliforms or *E. coli* means you need to take action to address the contamination and eliminate exposure.

Most coliform bacteria are a normal part of the environment. They do not cause disease but do indicate the water might be contaminated by soil or feces. Some rare types of coliforms, such as *E. coli* O157:H7, can cause serious illness. Although most *E. coli* O157:H7 outbreaks are from eating raw or undercooked food, cases from contaminated drinking water can occur, but are rare.

Seventy-two of the wells assessed in Coudersport were positive for the presence of coliform. Coliform bacteria are often used as a test for the presence of a wide range of bacteria, including fecal coliforms (e.g., *E. coli* or *Escherichia coli*), which can cause serious illness. Thirty-one water sources in Coudersport tested positive for the presence of fecal coliform bacteria. Ingesting fecal coliform bacteria, including *E. coli* can result in serious infections with symptoms including bloody diarrhea, stomach cramps, fever and vomiting.

Well owners whose well water sample tested positive for the presence of fecal coliform or E. coli should take immediate steps to eliminate their exposures to the contaminated water. ATSDR recommends treating water before its use, installing treatment to eliminate future exposures and regular testing to confirm the treated water is no longer contaminated with pathogens.

Well owners whose well water tested positive for the presence of total coliform but not fecal coliform or E. coli should monitor their well on a regular basis and consider treatment to improve water quality and to reduce the presence of bacteria in their drinking water.

While the presence of total coliforms does not indicate that illness will result from ingesting the untreated groundwater, it does suggest that the water be treated to eliminate exposures and reduce the presence of bacteria. The presence of fecal coliform or *e. coli* indicates an immediate public health concern and users should treat the water before its use to reduce the risk of serious illness.

Community Concerns

Specific environmental health concerns led Coudersport residents to petition ATSDR for technical assistance related to the JKLM injection event, particularly regarding chemical exposures and the potential for health effects from those exposures. This health consultation provides our evaluation of the available environmental information and the potential public health impacts that exposures may have caused. Additional specific concerns are also addressed in Appendix D. Following each concern, ATSDR provides a specific response, when possible. The community concerns expressed in Appendix D are limited to the petitioner's written concerns and a brief telephone discussion with an associate of the petitioner. If additional concerns relevant to this drinking water evaluation are provided to ATSDR during the public comment period for this document, ATSDR will incorporate those concerns and Agency responses in the final health consultation document.

Data Limitations

ATSDR recognizes the data available to assess exposures were limited in such a way as to affect our ability to fully assess the potential for health effects from groundwater exposures to chemicals in the Coudersport area water wells, including:

There are temporal and spatial data limitations – Due to variability in timing and frequency of sampling, we cannot be certain that we have samples from all impacted water sources from the beginning of the release until groundwater impacts were resolved. We do not have water quality measurements for these same groundwater wells and springs prior to the JKLM release, so we are not sure what contaminants and concentrations routinely exist in the groundwater wells and springs.

ATSDR cannot determine whether all JKLM-related contaminant exposures or longer-term groundwater quality issues were fully assessed. The JKLM-related contaminants were detected in samples for a period of less than six months (September 2015 through February 2016). However, it cannot be determined with the data set whether or for how long JKLM-related contaminants caused naturally-occurring chemicals to mobilize in the groundwater. It can also not be determined with the available data set whether naturally-occurring contaminants were already present at similar concentrations detected in these water sources before the JKLM release occurred.

Due to samples being collected over limited and varying time frames for each well and spring, ATSDR cannot determine exposure durations or chronic exposure concentrations for all exposure locations. Due to these sampling limitations, some contaminant exposure durations were assessed for both chronic (greater than one year) and intermediate (less than one year, more than two weeks) time frames, including aluminum, barium, lead, lithium, manganese, and sodium.

Proprietary chemical information was not provided – ATSDR has concluded that exposures to JKLM-injected products (i.e., isopropanol mixture) have occurred (see Conclusion 1); however, ATSDR does not have sufficient information to determine what other chemicals were in the injected mixtures that residents were exposed to. ATSDR also does not know the duration or concentration of exposure to these chemicals.

Conclusions

Based on the available data, ATSDR concludes the plume of contamination due to the JKLM release was diluted and degraded quickly in the aquifer.

A limited number of drinking water wells and surface water bodies were directly impacted by the release for less than six months.

Exposures to JKLM-related chemicals in drinking water were of short duration and at concentrations where most exposures were not expected to result in adverse health effects. Exposures to one JKLM-related chemical in one private groundwater well were high enough to cause temporary adverse health effects at one residence via inhalation while showering.

Surfactants were detected in surface water bodies (creeks and ponds), but at lower concentrations than were detected in groundwater sources; only a small number of groundwater sources had surfactant detections. Surfactants are compounds used in soaps, detergents, lubricants, and other emulsifiers.

ATSDR reached three specific conclusions related to exposures to chemicals and one conclusion related to exposure to bacteria in drinking water in the Coudersport area:

1. Isopropanol was detected in three private groundwater wells. The maximum level of isopropanol detected in one of these private wells was high enough to be of health concern from inhalation exposures during household water use (e.g., showering). The levels of isopropanol in the two other wells were below concentrations where health effects may be expected. Isopropanol is a contaminant that was released to groundwater by JKLM during this incident.

Based on the available sampling data, people were only exposed to isopropanol in their drinking water supplies for a short time. ATSDR does not expect any adverse health effects from *drinking* these levels of isopropanol for a short period of time in any of the three wells with isopropanol detections.

Based on results from a computer-based shower model that uses chemical concentrations in water, estimated inhalation exposure concentrations (showering plus bathroom time), for one residence exceeded an acute inhalation screening level. Temporary health effects, including eye, nose, and throat irritation, may have occurred from acute exposures to isopropanol at this residence. People with diabetes, and/or pre-existing eye, skin, respiratory, or neurological conditions, could be more sensitive to this chemical exposure. We expect some variability in people's responses to breathing this modeled level of isopropanol in air. While some individuals might experience short-term health effects, others may not. Isopropanol detected in other wells were not detected at concentrations of health concern from inhalation or ingestion.

2. People who consumed water contaminated with bromide, iron, lead, lithium, manganese or sodium may be at risk for harmful non-cancer health effects associated with these chemicals.

Bromide: Levels of bromide in three drinking water sources exceeded the World Health Organization (WHO) acceptable daily intake (ADI) level for bromide. However, estimated exposure doses were below the conservative no observed adverse effect level (NOAEL) of 4 milligrams per kilogram per day (mg/kg/day).

Iron: Water samples from 12 drinking water sources exceeded the EPA regional screening level (RSL) of 1,400 micrograms per liter (μg/L) and twenty-nine drinking water sources exceeded the EPA secondary maximum contaminant level (MCL) of 300 μg/L.

Exposures to the higher iron concentrations found in the 12 drinking water sources are not likely to result in adverse health effects in healthy residents. However, individuals with hemochromatosis, a rare inherited disease, may be at risk from these increased iron exposures from drinking water.

Lead: Lead in drinking water at any level should be reduced or removed. Fifty-six (56) of the Coudersport drinking water sources had detectable levels of lead, nineteen of which exceed the EPA action level for public drinking water of 15 μg/L. Chronic exposure to low lead levels in children has been shown to cause effects on the central nervous system, which can result in deficits in intelligence, behavior, and school performance. Health effects from lead exposure in children and unborn fetuses include both physical and mental impairments, hearing difficulties, impaired neurological development, and reduced birth weights and gestational age.

Lithium: Seven drinking water sources had lithium detections exceeding the EPA RSL of 40 μg/L. There is very little toxicological data on lithium exposures in young children. The potential for adverse health effects in sensitive subpopulations (patients undergoing lithium treatment, children, pregnant women, people with significant renal or cardiovascular disease, or individuals susceptible to dehydration or sodium depletion with concurrent long-term use of medications) is uncertain because of the lack of relevant study data.

Manganese: Manganese concentrations exceeded health based screening values in six drinking water sources. Chronic child and adult manganese exposure doses at one private drinking water well exceeded the lowest observed adverse effect levels (LOAEL). Chronic manganese exposure doses at two other private drinking water wells, when including additional exposures to manganese from food sources, exceeded the LOAEL for children under three. The EPA short-term advisory level is exceeded for adults consuming water from two private drinking water wells and for children consuming water from five private drinking water wells. High levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember.

Sodium: Exposures to sodium from Coudersport drinking water sources sampled at this site (without consideration of additional sodium intake from food sources) do not exceed recommended U.S. Departments of Health and Human Services and Agriculture (HHS/USDA) dietary guideline of 2,300 mg/day. However, twenty-three (23) drinking water sources exceeded the EPA drinking water advisory level for sodium (20 mg/L) in public drinking water. Individuals on sodium restricted diets or individuals with infants drinking this water should discuss their drinking water sodium results with their physician.

3. Health effects are not expected from exposures to other chemicals assessed in Coudersport area drinking water sources.

Although concentrations of **acetone, aluminum** and **barium** in Coudersport drinking water exceeded health-based screening values, ATSDR's analysis of the calculated daily exposure doses for each of these chemicals were below minimal risk levels (MRL) for both children and adults. An MRL is a daily exposure dose below which health effects are not expected to occur.

The one-time **benzene** detection in drinking water was below the EPA 10-day health advisory level.

All other assessed chemicals were below health-based screening values.

4. Biological contamination was found in a number of the drinking water sources that were tested.

Thirty-one water sources were positive for the presence of fecal coliform bacteria. Fecal coliform and *E. coli* can cause severe illness following acute exposures. Ingesting fecal coliform bacteria, including *E. coli*, can result in serious infections with symptoms including, but not limited to, bloody diarrhea, stomach cramps, fever and vomiting.

Recommendations and Next Steps

General Recommendations

Install treatment and continue to monitor: ATSDR recommends that private well owners with elevated levels of lead, lithium, manganese or sodium take steps to reduce exposures to these chemicals in their drinking water. This includes working with water quality treatment professionals to install treatment systems specifically designed to remove these contaminants. In addition, ATSDR recommends that all private well owners continue to monitor the quality of their residential well water.

The Penn State Extension Program provides low cost well testing and offers a specific gas/oil water testing package. Further information on Penn State's private water well testing program can be obtained from the Potter County Penn State Extension Office (814-274-8540; PotterExt@psu.edu) or the Penn State Extension Lab Testing website (http://agsci.psu.edu/aasl/water-testing). Penn State has also developed a fact sheet with specific recommendations for analytes appropriate to include in drinking water testing; the fact sheet can be found at: http://extension.psu.edu/natural-resources/water/marcellus-shale/drinking-water/testing-drinking-water-supplies-near-gas-drilling-activity/extension_publication_file.

Health Education/Outreach: In early 2016, soon after accepting the petition, ATSDR attempted to notify all residents with detected fecal coliform/E.coli contamination in their water supplies and residents with lead concentrations in their drinking water above the EPA public water supply action level of 15 µg/L. However, the contact information obtained by ATSDR was limited to a few residents in this rural area. ATSDR is working with PADEP to determine if additional contact information is available. ATSDR regional staff will continue to acquire contact information and conduct outreach, including distribution through U.S. mail service of this health consultation, to inform residents of contaminants that are of health concern in their drinking water.

ATSDR recommends that local and state environmental and public health agencies continue to inform residents with drinking water wells of the importance of regular water testing, and the responsibilities of all stakeholders (local government, industry, regulators, residents) involved in these types of incidents.

Planning and Preparedness: ATSDR recommends that drillers and state regulators develop site-specific procedures that protect the public from exposure to chemicals injected into open boreholes to recover drill bits and other 'lost' items.

Chemical-Specific Recommendations

Iron: Individuals with hemochromatosis, a rare inherited disease, should consult with their health professionals as appropriate to discuss the additional iron in their diet from well water.

Lithium and Sodium: Residents consuming well water with elevated lithium or sodium should inform their physician of these additional exposures through groundwater. This is especially important for residences with sensitive subpopulations (e.g., patients undergoing lithium treatment or under a sodium-reduced diet, infants/children, pregnant women, those with significant renal or cardiovascular disease, etc.).

Lead: Residents with lead in their drinking water above 15 µg/L (0.015 mg/L), should take immediate steps to eliminate or reduce their exposures to as low as achievable, either through installing lead-specific treatment, or by using an alternative drinking water source. ATSDR staff will continue to try to reach homeowners with lead detections in their well water above the EPA public water action level of 15 µg/L (0.015 mg/L). The following provides general recommendations for exposures to lead:

Reduce lead exposure: Because no level of lead in children's blood has been proven safe, ATSDR and CDC recommend reducing lead exposure wherever possible. ATSDR recommends that parents or guardians immediately reduce their own and their children's ingestion of lead in their drinking water and from other sources such as flaking or peeling lead paint and dust. See https://www.cdc.gov/nceh/lead/tips.htm for suggestions on reducing exposure to lead paint and dust.

*Reduce lead absorption***:** To help decrease lead absorption from any swallowed source, eat a nutritious diet including several small meals per day (appropriate for age and growth) rich in iron, calcium, vitamins C & D and zinc from such foods as dairy products, green vegetables, and lean meats. Proper nutrition is particularly important for children and pregnant women.

*Water filtration***:** ATSDR recommends homeowners use water filtration/treatment explicitly designed to reduce lead concentrations in residential well water supplies with detectable lead concentrations.

Blood lead screening: Consistent with statewide childhood blood lead screening guidelines, all families are encouraged to discuss blood lead screening for children six years of age and under with their health care provider. This is especially recommended for families whose home drinking water supply has lead detected above 15 µg/L.

Manganese: The following table provides general recommendations for manganese in drinking water.

General Public Health Recommendations for Manganese in Drinking Water

Manganese Concentration	**Recommendation**
300 µg/L or less	Routine water well monitoring, including analyses for manganese
300 to 500 µg/L	Infants (birth to 1 year) use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.
>500 µg/L	Infants and children use bottled water or use appropriate and properly maintained water treatment system with bi-annual water quality monitoring.
>1,000 µg/L	All age groups use bottled water or appropriate and properly maintained water treatment system with bi-annual water quality monitoring.

Bacteria-Specific (Coliform and E. Coli) Recommendations

ATSDR recommends that owners and operators of drinking water sources (i.e., wells and springs) that tested positive for the presence of fecal coliform or *E. coli* take immediate steps to eliminate exposures to the contaminated water, including installing treatment. Residents with bacterial contamination should evaluate their wellhead area and take steps to control any nearby sources that may be contributing to the bacterial contamination in the well. Well owners whose well water tested positive for the presence of total coliform but not fecal coliform or *E. coli* should monitor their well on a regular basis and consider treatment to improve water quality and to reduce the presence of bacteria in their drinking water.

More Information

For further information about this health consultation, please call ATSDR at 1-800-CDC-INFO and ask for information about the "JKLM Coudersport Site." If you have concerns about your health, contact your health care provider.

Public Health Action Plan

ATSDR has conducted outreach activities to inform particular residents that lead concentrations in their drinking water were in excess of the EPA public water supply action level of 15 µg/L. However, due to limited contact information available to ATSDR, ATSDR was not able to reach many of these residents. ATSDR is working with the state Department of Environmental Protection to determine if additional contact information is available. ATSDR regional staff will continue to attempt to acquire contact information and conduct outreach to inform residents of contaminants that are of health concern in their drinking water.

ATSDR will make this health consultation available to the public for a three-month comment period before incorporating public comments into the final version of this health consultation. ATSDR will make the final version of this health consultation available to the public via the ATSDR website, by distributing copies to interested community members and agency representatives, and by providing copies to the local library and the Coudersport government office building.

ATSDR will remain available to discuss any public health questions or concerns related to the site with community members and local, state, and federal authorities.

Private Well Testing

Many people in the United States receive their water from private ground water wells and springs. EPA regulations that protect public drinking water systems do not apply to privately owned wells. As a result, owners of private wells are responsible for ensuring that their water is safe from contaminants (CDC 2014). However, other regulations, such as state-specific oil and gas rules provide certain protections for private well owners. As a prudent public health measure, ATSDR recommends that all homeowners who use water from private wells, and in particular those in areas near gas drilling activity, have their wells routinely tested. The Penn State Extension Program provides low cost well testing and offers a specific gas/oil water testing package. Further information on the private water well testing program can be obtained from the Potter County Penn State Extension Office (814-274-8540; PotterExt@psu.edu) or the Penn State Extension Lab Testing website (http://agsci.psu.edu/aasl/water-testing). Penn State has also developed a fact sheet with discussion of specific recommendations for analytes appropriate to include in drinking water testing; the fact sheet can be found at: http://extension.psu.edu/natural-resources/water/marcellus-shale/drinking-water/testing-drinking-water-supplies-near-gas-drilling-activity/extension_publication_file.

Site Team

Division of Community Health Investigations, Eastern Branch

Robert H. Helverson, MS
Region 3 Representative

Lora Siegmann Werner, MPH
Regional Director, Region 3

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2012. ATSDR Record of Activity (AROA) Technical Assistance Document issued to EPA Region 3. Atlanta, GA: U.S. Department of Health and Human Services. March 23.

ATSDR. 2008. Toxicological profile for aluminum (updated). Atlanta, GA: US Department of Health and Human Services. September.

ATSDR. 2007. Toxicological profile for barium (updated). Atlanta, GA: US Department of Health and Human Services. August.

ATSDR. 2007b. Toxicological profile for benzene. Atlanta, GA: US Department of Health and Human Services. August.

ATSDR. 2007a. Division of Toxicology and Environmental Medicine ToxFAQs for Lead. Atlanta, GA: US Department of Health and Human Services. Online at http://www.atsdr.cdc.gov/tfacts13.pdf

ATSDR. 2005. Public Health Assessment Guidance Manual (Update). Atlanta, GA: Department of Health and Human Services. January.

ATSDR. 1994. Toxicological profile for acetone (updated). Atlanta, GA: US Department of Health and Human Services. May.

Aral, H. and Vecchio-Sadus, A. 2008. Toxicity of lithium to humans and the environment—A literature review. Ecotoxicology and Environmental Safety. Volume 70, issue 3: 349–356. July. Available online at: http://www.sciencedirect.com/science/article/pii/S0147651308000742

Canfield, RL. et al. 2003. Intellectual Impairment in Children with Blood Lead Concentrations below 10 µg per Deciliter. New England Journal of Medicine. 348:1517-1526. April 17. Online at http://www.nejm.org/doi/full/10.1056/NEJMoa022848

Centers for Disease Control and Prevention (CDC). 2012. Childhood Lead Poisoning Prevention Program. Online at http://www.cdc.gov/nceh/lead/about/program.htm

Clark, LH; Setzer, RW; Barton, HA. 2004. Framework for evaluation of physiologically-based pharmacokinetic models for use in safety or risk assessment. Risk Anal 24: 1697-1717. http://dx.doi.org/10.1111/j.0272-4332.2004.00561.x

Clewell, HJ, III; Gentry, PR; Gearhart, JM; Covington, TR; Banton, MI; Andersen, ME. 2001. Development of a physiologically based pharmacokinetic model of isopropanol and its metabolite acetone. Toxicol Sci 63: 160-172.

U.S. Environmental Protection Agency (EPA). 2017. National Secondary Drinking Water Regulations. Accessed on January 26, 2017 at: https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals

EPA. 2012. 2012 Edition of the Drinking Water Standards and Health Advisories. Washington, DC: U.S. Environmental Protection Agency, Office of Water. EPA-822-S-12-001. April.

EPA. 2008. Provisional Peer Reviewed Toxicity Values for Lithium. Superfund Health Risk Technical Support Center, National Center for Environmental Assessment, Office of Research and Development. Online at http://hhpprtv.ornl.gov/issue_papers/Lithium.pdf

EPA. 2005. Integrated Risk Information System (IRIS) for barium and compounds. Online at https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=10

EPA. 2004. Drinking Water Health Advisory for Manganese. Washington, DC: U.S. Environmental Protection Agency, Office of Water. EPA-822-R-04-003. January 2004.

Gentry, PR; Covington, TR; Andersen, ME; Clewell, HJ, III. 2002. Application of a physiologically based pharmacokinetic model for isopropanol in the derivation of a reference dose and reference concentration [Review]. Regul Toxicol Pharmacol 36: 51-68. http://dx.doi.org/10.1006/rtph.2002.1540

Gentry, PR; Covington, TR; III, CH; Anderson, ME. 2003. Application of a physiologically based pharmacokinetic model for reference dose and reference concentration estimation for acetone. J Toxicol Environ Health A 66: 2209-2225. http://dx.doi.org/10.1080/713853996

Hayes, T. 2009. Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale Gas, Final Report, Marcellus Shale Coalition, Gas Technology Institute (GTI). Available at: http://eidmarcellus.org/wpcontent/uploads/2012/11/MSCommission-Report.pdf

Institute of Medicine (IOM). 2004. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate. Washington, DC: National Academies Press.

IOM. 2000. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Washington, DC: National Academies Press.

Jusko ,T.A., et al. 2008. Blood lead concentrations < 10 μg/dL and child intelligence at 6 years of age. Env. Health Perspect. Feb: 116(2):243-8. Online at https://www.ncbi.nlm.nih.gov/pubmed/18288325

Kondakis, X.G., N. Makris, M. Leotsinidis, M. Prinou, and T. Papapetropoulos. 1989. Possible health effects of high manganese concentration in drinking water. Arch. Environ. Health 44: 175-178.

Lanphear, et al. 2005. Low-Level Environmental Lead Exposure and Children's Intellectual Function: An International Pooled Analysis. Environ Health Perspective 113(7). Online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1257652/

Ludlow, R.A. and Loper, C.A. 2013. Chester County Ground-Water Atlas, Chester County, Pennsylvania. U.S. Department of the Interior and U.S. Geological Survey. Open-File Report 03-442. August.

National Toxicology Program (NTP), Public Health Service, U.S. Department of Health and Human Services. 1994. NTP technical report on the toxicology and carcinogenesis studies of barium chloride dihydrate (CAS no. 10326-27-9) in F344/N rats and B6C3F1 mice (drinking water studies). NTP TR 432. Research Triangle Park, NC. NIH pub. no. 94-3163. NTIS pub PB94-214178.

Nelson, K.W., Ege, J.F. Jr, Ross. M., Woodman. L.E., Silverman L. 1943. Sensory Response to Certain Industrial Solvent Vapors. J Ind Hyg Toxicol; 25(7):282-285.

California Office of Environmental Health Hazard Assessment (OEHHA). 2000. Appendix D.3 Acute RELs and toxicity summaries using the previous version of Hot Spot Risk Assessment guidelines (OEHHA 1999). March. Accessed on May 9, 2107. Available online at https://oehha.ca.gov/media/downloads/crnr/appendixd2final.pdf

Pennsylvania Department of Environmental Protection (PADEP). 2011. Statewide Health Standards: Medium Specific Concentrations. Online at: https://www.dep.pa.gov/Business/Land/LandRecycling/Standards-Guidance-Procedures/Pages/Statewide-Health-Standards.aspx

PADEP. 2015. Notice of Violation (NOV) issued by PADEP to JKLM LLC, Inc. September 30. Available online at: http://files.dep.state.pa.us/RegionalResources/NCRO/documents/201610240920.pdf

PADEP. 2016. 10/24/2016 Media Release: DEP Fines JKLM Energy LLC $472,317 for 2015 Potter County Surfactant Discharge. Available online at: http://www.media.pa.gov/pages/DEP_details.aspx?newsid=711

Schrauzer, G.N, 2002. Lithium: occurrence, dietary intakes, nutritional essentiality. Am. Coll. Nutr. 21 (1), 14–21.

Sloto, R.A. 2013. Baseline groundwater quality from 20 domestic wells in Sullivan County, Pennsylvania. 2012: U.S. Geological Survey Scientific Investigations Report 2013–5085, p. 27. Available at: http://pubs.usgs.gov/sir/2013/5085/.

U.S. Census. 2010. Available at https://datamapper.geo.census.gov/map.html

Wasserman, G. A., Liu, X., Parvez, F., Factor-Litvak, P., Ahsan, H., Levy, D., Graziano, J. H. 2011. Arsenic and manganese exposure and children's intellectual function. Neurotoxicology, 32(4), 450–457.

Wasserman GA, Liu X, Parvez F, et al. 2006. Water manganese exposure and children's intellectual function in Araihazar, Bangladesh. Environ Health Perspect.; 114(1):124-129.

Weiner, M.L., 1991. Overview of lithium toxicology. In: Schrauzer, G.N., Klippel, K.F. (Eds.), Lithium in Biology and Medicine. Hydrogen Substitution in Lithium-Aluminosilicates. VCH Verlag, Weinheim, pp. 83–99.

Woolf, A., Wright, R., Amarasiriwardena, C., & Bellinger, D. 2002. A child with chronic manganese exposure from drinking water. Environmental Health Perspectives, 110(6), 613–616.

World Health Organization (WHO). 2010. Bromide in drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality. Online at http://www.who.int/water_sanitation_health/dwq/chemicals/Fourth_Edition_Bromide_Final_January_2010.pdf

WHO. 2007. Desalination for Safe Water Supply: Guidance for the Health and Environmental Aspects Applicable to Desalination. Public Health and the Environment. Geneva. Online at http://www.who.int/water_sanitation_health/gdwqrevision/desalination.pdf

WHO. 2001. Guidelines for Drinking-Water Quality, Fourth Edition. Geneva.

Figures

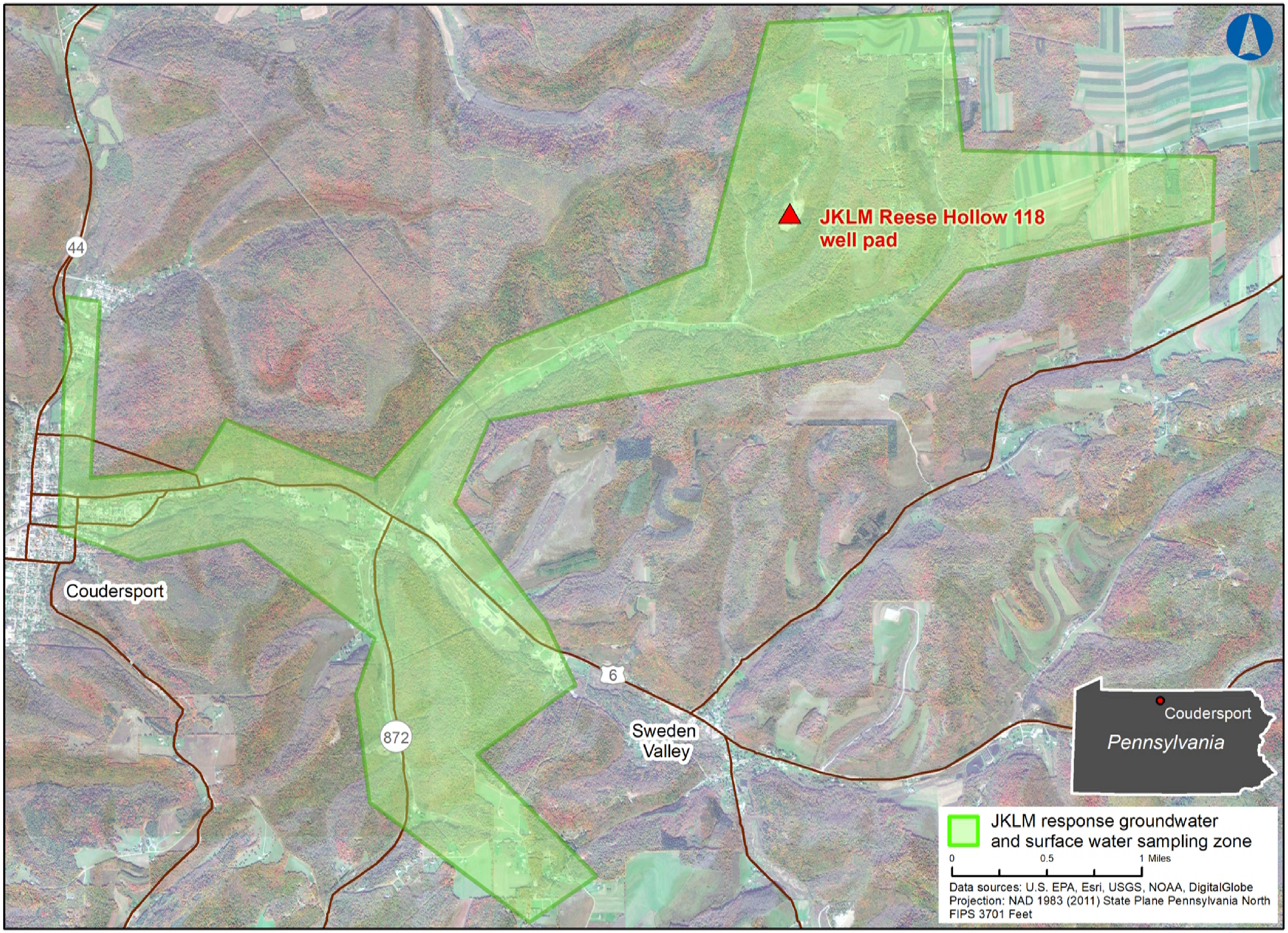
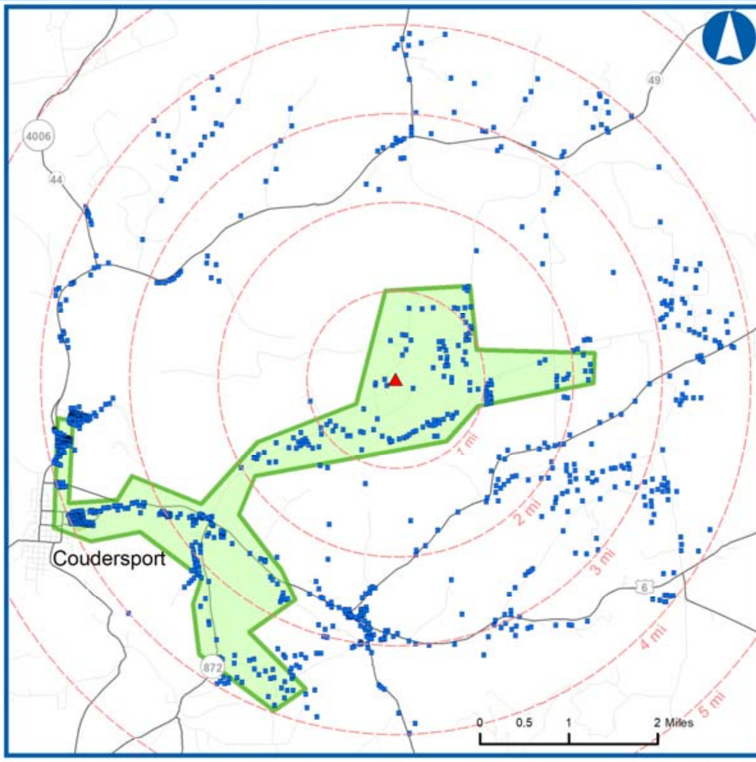


Figure 1. JKLM Site Location Map

GRASP

JKLM Coudersport Site
Potter County, Pennsylvania



Demographic Statistics
Within 4-mile buffer of site

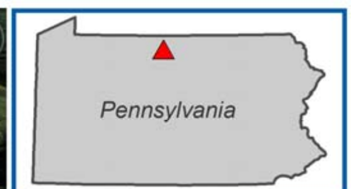
Measure	Estimate
Total Population	2,217
White Alone	2,175
Black Alone	3
Am. Indian & Alaska Native Alone	8
Asian Alone	10
Native Hawaiian & Other Pacific Islander Alone	0
Some Other Race Alone	5
Two or More Races	18
Hispanic or Latino	36
Children Aged 6 and Younger	185
Adults Aged 65 and Older	504
Females Aged 15 to 44	338
Housing Units	1,274

▲ JKLM Reese Hollow 118 well pad

▪ Residential dwelling within 4-mile buffer of site

□ JKLM response groundwater and surface water sampling zone

Data sources:
Demographic estimates: based on U.S. Census (2010)
Residential dwellings: digitized from DigitalGlobe imagery (2015)
Basemap: TomTom
Map projection: Pennsylvania State Plane (North)



The JKLM Coudersport Site is located in Potter County, Pennsylvania. The site is situated near the ridgeline of a hill.

The hillshade image at left depicts its position as seen looking from the south toward the north.

The blue dots indicate residential dwellings. The pink line indicates a 1-mile buffer around the site.

This image was created in Google Earth using 2 times vertical exaggeration. Contour lines are from Esri's USA Topo Maps (National Geographic Society, 2013).

Appendix A

Initial Screening
Maximum Contaminant Concentration Table

Table A1
Maximum Concentration Screening Table
Bold indicates contaminant of potential concern (COPC)

Contaminant	Screening Value	Screening Value Source	Maximum concentration	COPC?
Acetone	**6,300**	**child RMEG**	**19400**	**Y**
Aluminum	**7,000**	**child iEMEG**	**43700**	**Y**
Barium	**1,400**	**child iEMEG**	**1590**	**Y**
Benzene	**3.5**	**child cEMEG**	**7.65**	**Y**
Bromide	**2,000**	**WHO Child ADI**	**13000**	**Y**
Iron	**1,400**	**RSL (HQ=0.1)**	**61,600**	**Y**
Isopropanol	**41**	**RSL (HQ=0.1)**	**15000**	**Y**
Lead	**15**	**EPA Action Level**	**373**	**Y**
Lithium	**4/ 40**	**RSL (HQ=0.1)/(HQ=1.0)**	**110**	**Y**
Manganese	**300**	**EPA Health Advisory (HA)**	**2580**	**Y**
Sodium	**20,000**	**IOM**	**146000**	**Y**
E. Coli (MPN/100 ml)	**0 (fecal)**	**MCL**	**200.5**	**Y**
Total Coliforms (MPN/100 ml)	**2 (total)**	**MCL**	**802**	**Y**
Benzo (a) anthracene	0.034	RSL (HQ=1.0)	0.552	N*
Benzo (a) pyrene	0.2	MCL	0.895	N*
Benzo (b) fluoranthene	0.034	RSL (HQ=1.0)	1.84	N*
Benzo (g,h,i) perylene	0.26	PADEP MSC	0.723	N*
Benzo (k) fluoranthene	0.034	RSL (HQ=1.0)	0.63	N*
Indeno (1,2,3-cd) pyrene	0.034	RSL (HQ=1.0)	0.767	N*
Arsenic	35	child aEMEG	0.547	N
Strontium	4,200	child cEMEG	0.878	N
Nitrate-Nitrite (as N)	28,000	child cEMEG	13000	N
Fluoride	800	RSL (HQ=1.0)	270	N
Sulfate as SO4	250,000	SMCL	32800	N
m,p-Xylene	1,400	child RMEG	4.41	N
o-Xylene	1,400	child RMEG	0.830	N
Xylenes (total)	1,400	child RMEG	3.98	N
Ethylbenzene	2,800	child iEMEG	11.8	N
Methane	7,000	USGS/Dept. of Interior#	4900	N
1,1-Dichloroethane	14	RSL (HQ=0.1)	0.69	N
2-Butanone	6,000	child RMEG	14.2	N
2-Hexanone	50	child RMEG	1.25	N
Chrysene	3.4	RSL (HQ=1.0)	1.4	N
Phenanthrene	1,100	PADEP MSC	1.28	N
Pyrene	120	RSL (HQ=1.0)	2.98	N
Bis(2-ethylhexyl) adipate	6,000	child RMEG	4.59	N
Bis(2-ethylhexyl)phthalate	700	child iEMEG	24.9	N

Contaminant	Screening Value	Screening Value Source	Maximum concentration	COPC?
Bromodichloromethane	280	child aEMEG	0.84	N
Butyl benzyl phthalate	2000	child RMEG	0.545 J	N
Chloroform	100	child cEMEG	5.48	N
Chloromethane	19/190	RSL (HQ=0.1)	0.830	N
Di-n-butyl phthalate	1000	Child RMEG	23.9	N
Pebulate	100	RSL (HQ=0.1)	0.318	N
Styrene	2000	child RMEG	8.43	N
Tert-butyl alcohol	120	Mass ORSGL	8.42	N
Total Dissolved Solids	500,000	SMCL	<500,000	N
pH (in pH units)	6.5-8.5	SMCL	6.16-9.09 (range)	N
MBAS	NA	NA	116000	N

Notes: * = eliminated as COPC due to short exposure duration; # = safety screening level for offgasing into indoor air; aEMEG = ATSDR acute environmental media evaluation guideline; cEMEG = ATSDR chronic environmental media evaluation guideline; HQ = toxicity hazard quotient; iEMEG = ATSDR intermediate environmental media evaluation guideline; IOM = Institute of Medicine; J = reported value is an estimate. Actual concentration may be higher or lower than reported; Mass ORSGL = Massachusetts Office of Research and Standards Guideline; MCL = EPA regulatory maximum contaminant level in public water; MCLG = EPA maximum contaminant level goal; MPN/100 mL = most probable number of coliform per 100 ml; NA = not available; RMEG = ATSDR chronic screening value based on EPA Reference dose (RfD); RSL = EPA regional screening level; SMCL = EPA secondary maximum contaminant level (non-regulatory); USGS = U.S. Geological Survey; WHO ADI = World Health Organization Acceptable Daily Intake

Appendix B

1. **Exposure Pathway Assessment**
2. **ATSDR Health Assessment Process**
3. **Coudersport Drinking Water Exposure Durations**
4. **Detection Information for Coudersport COPCs**

This appendix provides information in four sections. The *Exposure Pathway Assessment* section provides criteria for identifying a completed contaminant exposure pathway. This was the criteria used to confirm a completed pathway exists from the release point to human receptors in Coudersport. Section 2 provides general information about the *ATSDR Health Assessment Process.* Section 3 provides *Coudersport Exposure Duration Information* for specific wells with COPC detections. And, Section 4 provides additional *Detection Information for Coudersport COPCs.*

1. Exposure Pathway Assessment

Exposure pathways consist of five elements: a contamination *source*; *transport* of the contaminant through an environmental medium like air, soil, or water; an *exposure point* where people can come in contact with the contaminant; an *exposure route* whereby the contaminant can be taken into the body; and an *exposed population* of people actually coming in contact with site contaminants [ATSDR 2005].

Completed exposure pathways are those for which all five pathway elements are evident. If one or more elements is missing or has been stopped (for example, by preventing transport of the chemical from the source to the exposure point), the pathway is *incomplete*. Exposure cannot occur for incomplete exposure pathways. For *potential* exposure pathways, exposure appears possible, but one or more of the elements is not clearly defined.

The completed exposure pathway from the source of contamination (Reese Hollow 118 well pad) to individual residential wells in Coudersport began on or before September 21, 2015 and continued for impacted well owners until alternate sources of drinking water was supplied or household water treatment was installed and deemed effective.

A completed exposure pathway does not necessarily mean that harmful health effects will occur. A chemical's ability to harm health depends on many factors, including how much of the chemical is present, how long and how often a person is exposed to the chemical, and how toxic the chemical is. Further evaluation of the specific exposure occurring is needed to determine whether the exposure could cause harmful effects.

2. ATSDR Health Assessment Process

The process by which ATSDR evaluates the potential for adverse health effects to result from exposure to contaminants is described briefly below, focusing on the groundwater pathway of concern for the community around JKLM Reese Hollow 118 well pad.

ATSDR first screens water sampling results against chemical-specific, health-based screening values or comparison values (CVs). See Appendix A, Table A1, for results of initial data screening of Coudersport data set. CVs are concentrations of chemicals in drinking water below which no harmful health effects are expected to occur, even with continual exposure. If a chemical is present at a level higher than the corresponding CV, it does not mean that harmful health effects will occur, but that exposures to the chemical need further evaluation. CVs may include values derived by ATSDR and values developed by other state, federal, or international organizations (e.g., World Health Organization). CVs are specific to exposure durations, which include acute durations, where daily exposures occur for up to two weeks; intermediate exposures, where daily exposures occur for more than two weeks but less than one year; and chronic exposures, where daily exposures occur for a lifetime (i.e., 78 years).

For chemicals in drinking water that exceed CVs, ATSDR calculates exposure doses. Exposure doses are estimated amounts of a chemical that people could take up into their bodies, on an equivalent body weight basis. The estimated dose is compared to a corresponding health guideline representing a dose below which no harmful, non-cancer health effects would be expected. The potential for doses that exceed health guidelines to cause harmful effects is determined by comparing the site-specific dose to known health effect levels identified in ATSDR's toxicological profiles, EPA's Integrated Risk Information System, or other scientific literature. For cancer-causing substances, an estimate of the increased risk of developing cancer from the exposure is calculated by multiplying the dose by an appropriate cancer slope factor. ATSDR evaluates cancer risks when exposures to carcinogens occur for one year or more (i.e., chronic exposure durations). Because the data indicated that exposures to carcinogens were of short duration in Coudersport, these data were not screened against ATSDR cancer risk evaluation guidelines (e.g., benzene, polycyclic aromatic hydrocarbons or PAHs).

3. Coudersport Drinking Water Exposure Durations

The maximum number of days of human exposure to JKLM-related contaminants is not certain; however, ATSDR evaluated the environmental data to estimate the maximum duration.

Potential exposure durations span from a few days to less than six months, which is the duration that sampling for JKLM-related contaminants occurred (September 2015 through February 2016. February 2016 is the date when contaminants had not been detected for a sufficient number of sampling rounds over time).

ATSDR considers exposures of less than two weeks and less than one year as acute and intermediate time durations, respectively. Exposures greater than one year are considered chronic exposures. Contaminants related to the JKLM Reese Hollow 118 well pad (i.e., isopropanol, acetone [a breakdown product of isopropanol], surfactants by MBAS test, benzene, toluene, ethylbenzene, and xylenes [BTEX]) were detected in select wells for a short period of time. The maximum durations that these specific contaminants were detected in drinking water wells were much shorter than maximum potential exposure period of six months and apparently two weeks or less in the impacted wells (based on available data). As noted above, the exposures were also mitigated as soon as a chemical's presence was identified in a drinking water well, thereby reducing exposure durations in most cases to a few days. Due to uncertainty about the effectiveness of previously-installed household water treatment systems, ATSDR cannot be certain whether residents were exposed to the maximum concentrations of contaminants in groundwater.

Based on evaluation of exposure durations for JKLM-related chemicals (isopropanol, benzene, ethylbenzene, xylenes and acetone), acute or intermediate exposure duration health-based screening values (CVs) were used. In the absence of an acute or intermediate screening value, ATSDR used chronic exposure screening values as the basis for screening the environmental data.

4. Detection Information for Coudersport COPCs

Detection information for the nine contaminants of potential concern (COPC) and bacterial contamination is provided in this section.

Acetone

Acetone was detected in fourteen water source sampling locations (12 groundwater wells, the Charles Cole Hospital spring #83, and in Hershey Pond). Acetone concentrations ranged from not detected in a majority of the samples up to 19,400 µg/L (19.4 mg/L) in residential well (RW) #1. The maximum value of 19,400 µg/L was in the pre-treatment sample; the post-treatment concentration (i.e., exposure concentration) was 230 µg/L; and the 95UCL for acetone exposures from this well, when excluding pre-treatment, non-exposure data, was 194 µg/L). The second highest acetone concentration in well water was detected in RW #40 at 3,630 µg/L (3.63 mg/L). ATSDR's health-based screening value for intermediate exposures (i.e., less than one year exposure duration) to acetone is 14,000 µg/L (14 mg/L) for children and 52,000 µg/L (52 mg/L) for adults. Only the maximum pre-treatment sample result from well RW #1 exceeded a health-based screening value for drinking water exposures to acetone.

Aluminum

Aluminum was detected in private residential drinking water wells ranging from below levels of analytical detection (50 µg/L or 0.05 mg/L) to 43,700 µg/L (43.7 mg/L). One well (RW #2) exceeded the ATSDR intermediate exposure duration environmental media evaluation guideline (iEMEG) of 7,000 µg/L (7 mg/L) and 26,000 µg/L for children and adults, respectively. The iEMEG was not exceeded in any other Coudersport well samples.

The EPA secondary maximum contaminant level (SMCL) for aluminum is 50-200 µg/L. This is a non-regulatory guideline for water suppliers that addresses the aesthetics of drinking water (i.e., color, taste, smell, staining of fixtures). There were a number of wells in the site groundwater assessment area that had aluminum concentrations in excess of the SMCL. Aluminum concentrations above the EPA SMCL may discolor well water (EPA 2017), but are not of potential health concern until concentrations exceed health-based screening values (e.g., iEMEG).

Barium

The ATSDR intermediate EMEG (iEMEG) for barium is 1,400 µg/L (1.4 mg/L) and 5,200 µg/L (5.2 mg/L) for children and adults, respectively, and is based on the more soluble forms of barium (soluble salts). ATSDR does not have sufficient information to determine the chemical form of the barium detected in Coudersport groundwater samples.

Barium was detected in two residential wells (RW#4 and #5) with maximum barium concentrations of 1,590 and 1,450 µg/L (1.59 and 1.45 mg/L), respectively, exceeding the children's iEMEG of 1,400 µg/L (1.4 mg/L). Neither the EPA MCL of 2,000 µg/L (2 mg/L) nor the ATSDR adult iEMEG of 5,200 µg/L (5.2 mg/L) were exceeded in any Coudersport wells assessed in this document. All other Coudersport wells had maximum barium concentrations below health-based CVs.

Benzene

Benzene was detected once each at two separate sampling locations on different dates: RW#2 had a single benzene detection of 7.65 µg/L on September 21, 2015, and a pond sample had a single benzene detection of 0.98 µg/L on 9/24/2015. Benzene exposures from drinking water were of short duration (less than 10 days), based on available data. The ATSDR child and adult *chronic* EMEGs are 3.5 and 13 µg/L, respectively. The ATSDR CREG is 0.44 µg/L. The EPA one-day and 10-day benzene health advisory value for drinking water is 200 µg/L (EPA 2012).

Bromide

Bromide was detected in three Coudersport residential wells (wells #2, #40, and #42) and two public water source wells (Coudersport Water Treatment Plant 2 source well and the Charles Cole Hospital South well, known as wells #82 and #84, respectively) with maximum concentrations in these wells ranging from 300 µg/L (0.3 mg/L) in well RW#82 to 13,000 µg/L (13 mg/L) in RW#2. Each well had only one detection of bromide from three or fewer rounds of bromide analyses per well.

Isopropanol

Three (3) of the Coudersport groundwater wells assessed had detectable levels of isopropanol. The maximum value of 15,000 µg/L (15 mg/L) was detected in RW#1, the well nearest the release point, exceeding the health-based screening value (CV) of 410 µg/L. Wells RW#2 (175 µg/L, or 0.175 mg/L) and RW#42 (101 µg/L or 0.101 mg/L) had singular detections of isopropanol at levels below the health based screening value of 410 µg/L. The CV for isopropanol is the EPA Regional Screening level (RSL), with a toxicity hazard quotient equal to 1. The RSL takes three exposure pathways for drinking water into account, including ingestion, dermal (i.e., skin contact), and inhalation exposures, and is based on chronic exposures. ATSDR has not identified an acute health-based screening value for isopropanol.

Iron

Twelve drinking water sources had iron detected above the EPA RSL of 1,400 µg/L. Residential well #2 (RW#2) had the maximum iron detection (61,600 µg/L) and the highest 95UCL for iron in this data set (6,200 µg/L). The maximum iron detection occurred on September 21, 2015, the same day other metals were at their maximum concentration, and surfactants, acetone, nitrates and other contaminants were detected in RW#2. Table B1 identifies water sources with iron exceeding the EPA regional screening level of 1,400 µg/L.

Table B1
Wells with iron exceeding EPA Regional
Screening Level of 1,400 µg/L

Well ID	Maximum Concentration (in µg/L)
RW#2	61,600
RW#38	8,690
RW#34	5,790
RW#1	3,690

RW#9	3,510
RW#69	2,080
RW#35	1,920
RW#26	1,570
RW#30	1,490
RW#12	1,480
RW#42	1,450
RW#95	1,430

Lead

Nineteen (19) water sources exceeded the EPA public water supply action level of 15 µg/L for lead (EPA 2012). Fifty-six (56) of the Coudersport groundwater wells (including the nineteen in excess of 15 µg/L) had detectable levels of lead (see Table 2 in main body of report). Five wells had lead concentrations exceeding 100 µg/L (RW #42 at 373 µg/L; RW #38 at 303 µg/L; RW #49 at 218 µg/L; RW #86 at 212 µg/L; and RW #59 at 144 µg/L). Based on sampling data accumulated in response to the JKLM incident, the lead concentrations in these wells are highly variable, including, no detectable lead during some sampling events of these same wells.

Lithium

Lithium concentrations in Coudersport area wells assessed following the JKLM event ranged from non-detect to 110 µg/L. Two groundwater wells (Charles Cole Hospital South – well #84 - at 110 µg/L and RW #17 at 78.4 µg/L) had a lithium detection exceeding the PADEP MSC of 73 µg/L. Seven groundwater wells had lithium detections exceeding the regional screening level of 40 µg/L, including RWs #17, #32, #61, and source wells #81, #82, and #84.

The EPA Provisional Peer-Reviewed Toxicology Value (PPRTV) for lithium is 0.002 mg/kg/day (EPA 2008). By applying standard EPA risk assessment inputs for body weight (15-kg body weight for children and daily water consumption of 0.78 liters per day for children), the drinking water-specific screening level based on the PPRTV is 40 µg/L for children. The PADEP medium-specific concentration (MSC) for used groundwater is 73 µg/L (PADEP 2011).

Manganese

Manganese concentrations in Coudersport area wells ranged from non-detect up to 2,580 µg/L (2.58 mg/L). Six wells (See Table B2) exceeded the manganese health-based screening value of 300 µg/L (0.3 mg/L). Thirty-one groundwater wells, including the six wells assessed below, had manganese levels above the SMCL of 50 µg/L. Untreated water from these RWs (#1, 2, 3, 12, 13, 26, 27, 30, 33, 34, 35, 38, 42, 43, 44, 45, 53, 54, 55, 62, 66, 69, 71, 75, 95, 101 and 107) and source wells (Coudersport public supply wells #81 and #82, and Charles Cole Memorial Hospital Leete Garage well #85 and supply well #91), may have unpalatable water at times and may cause staining of fixtures.

Table B2
Maximum Detected Manganese Levels
Coudersport, PA

Sampling Location (Residential Wells, RW)	Maximum Manganese Concentration in µg/L (sample date)	95UCL Manganese Concentration in µg/L (number of samples)	Notes
Well #35	2,580 (10/1/2015)	Insufficient data (n=1)	Only 1 round of sampling data
Well #71	415 (10/4/2015)	Insufficient data (n=1)	Only 1 round of sampling data
Well #34	376 (9/28/2015)	Insufficient data (n=1)	Only 1 round of sampling data
Well #2	1,110 (9/21/2015)	167 (n=30)	ND in pre-drill and <300 µg/L after 10/14/2015
Well #95	419 (9/30/2015)	168 (n=14)	<300 µg/L after 10/22/2015
Well #38	381 (9/26/2015)	Insufficient data (n=2)	2 rounds of sampling, <300 on 10/15/2015

Notes: * = non-detect values are quantified as the minimal detection limit divided by the square root of 2; µg/L = micrograms of manganese per liter of water; ND = manganese not detected above 0.003 µg/L; <300 µg/L = less than 300 µg/L; EPA drinking water advisory level is 300 µg/L; n = number of sampling rounds; 95UCL = 95^{th} upper confidence limit of the geometric mean

Sodium

Twenty-eight wells in the Coudersport area had sodium levels in excess of the EPA drinking water advisory level (see Table B3). Twenty of these wells have only one round of sodium sampling and analyses data; therefore, chronic sodium exposure concentrations from these twenty wells are uncertain. All other wells had sodium levels below the health-based screening level of 20,000 µg/L (20 mg/L).

Table B3
Sodium Concentrations in Wells Exceeding EPA Drinking Water Advisory Level
Coudersport Groundwater Wells

Sample Identifier	Maximum Concentration	95UCL (n)
well #84	146	129 (19)
well #69	82	79 (20)
well #82 (CWTP 2)	74.7	70 (20)
well #81 (CWTP 1E)	74	42 (20)
well #91	35.8	35 (19)
well #7	38.8	38 (4)
well #2	23.1	12 (25)
well #3	35.9	Insufficient data (n=2)
well #17	97.7	Insufficient data (n=1)
well #32	88.6	Insufficient data (n=1)
well #68	84.1	Insufficient data (n=1)
well #53	69.9	Insufficient data (n=1)
well #54	65	Insufficient data (n=1)

well #61	58.6	Insufficient data (n=1)
well #55	51.1	Insufficient data (n=1)
well #52	46.6	Insufficient data (n=1)
well #35	38.8	Insufficient data (n=1)
well #51	37.3	Insufficient data (n=1)
well #4	35.9	Insufficient data (n=1)
well #103	33.2	Insufficient data (n=1)
well #96	33.1	Insufficient data (n=1)
well #67	31.9	Insufficient data (n=1)
well #62	30.2	Insufficient data (n=1)
well #58	29.3	Insufficient data (n=1)
well #8	28.1	Insufficient data (n=1)
well #66	26.1	Insufficient data (n=1)
well #47	24.8	Insufficient data (n=1)
well #31	22.5	Insufficient data (n=1)

Notes: Concentrations in µg/L; n = number of samples analyzed for sodium from specific well; CWTP 1E = Coudersport Water Treatment Plant source well 1E; CWTP 2 = Coudersport Water Treatment Plant source well 2; Hosp. S = Charles Cole Memorial Hospital South source well

Coliform

Thirty-one wells were positive for the presence of fecal coliform bacteria. Coudersport area wells with total coliform or fecal coliform contamination are listed in Table B4.

Table B4
Fecal Coliform and Total Coliform Presence
Coudersport, PA

Fecal Coliform or *E. coli* Present (Water source #)	Total Coliform Present (water source #)
1, 2, 7, 9, 11, 19, 27, 31, 35, 38, 39, 40, 42, 44, 46, 49, 57, 59, 65, 70, 72, 83, 88, 89, 90, 92, 93, 94, 101, 107, 108	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 26, 28, 29, 30, 31, 35, 37, 38, 39, 40, 42, 44, 45, 50, 51, 52, 57, 59, 62, 63, 64, 65, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 85, 86, 87, 88, 89, 90, 92, 93, 94, 95, 97, 99, 100, 101, 103, 105

Notes: *= includes groundwater and springs sampled during JKLM response

Appendix C

Additional General Information on Contaminants of Potential Concern

Acetone
Acetone is a chemical that is found naturally in the environment and produced by industrial activities. Low levels of acetone are normally present in the body from the breakdown of fat; the body can use it in normal processes that make sugar and fat. Acetone is a colorless liquid with a distinct smell and taste (ATSDR 1994). Most people begin to detect the presence of acetone in water at 20,000 µg/L (20 mg/L). Acetone evaporates readily into the air and mixes well with water. Most acetone produced is used to make other chemicals that make plastics, fibers, and drugs. Acetone is also used to dissolve other substances (ATSDR 1994). At the JKLM Coudersport site, acetone was specifically assessed because it is an environmental degradation product of isopropanol, a chemical that was injected into the ground by JKLM at the Reese Hollow 118 well pad. Acetone is also the primary metabolite produced in the body following isopropanol exposures.

Aluminum
Aluminum is a naturally-occurring element that is a silvery-white, malleable and ductile metal. Aluminum is the most abundant metal in the earth's crust and it is widely distributed. Aluminum is a very reactive element and is never found as the free metal in nature. It is found combined with other elements, most commonly with oxygen, silicon, and fluorine. These chemical compounds are commonly found in soil, minerals (e.g., sapphires, rubies, turquoise), rocks (especially igneous rocks), and clays (ATSDR 2008).

Barium
Barium is present in a wide variety of food items including breads, peanut butter, cereals, pasta, fruits, vegetables, eggs, dairy products, and to a lesser extent in meats, poultry, and fish at levels from 10 µg/kg up to 3,000 µg/kg (ATSDR 2007). The highest concentrations of barium in food have been noted in peanut butter and peanuts (2,900 µg/kg) and Brazil nuts (3,000-4,000 µg/kg). Barium is present in many public drinking water supplies at an average level of 30 µg/L, but can be as high as 300 µg/L in some regions of the United Sates (ATSDR 2007). Barium is used as a filler in many paints and other industrial coatings, plastics, rubber products, brake linings, and in some sealants and adhesives (ATSDR 2007, WHO 2001).

In a 2009 study of Marcellus shale hydraulic fracturing flowback, total and dissolved barium was regularly detected in the flowback samples (Hayes 2009). Barite (a mineral composed primarily of barium sulfate with occasional traces of strontium and calcium) is used extensively in the oil industry as a constituent in drilling mud (ATSDR 2007, WHO 2001). Barium carbonate is often used as a rodenticide (ATSDR 2007). Barium sulfate is used extensively in the medical field as a contrast medium for diagnosing problems in the upper and lower GI tract (WHO 2001). As a medical contrast medium, it is often ingested in quantities of 400 grams or more. Since barium sulfate is virtually insoluble (only approximately 2,460 µg will dissolve in a liter of water at 25 ºC), it generally causes no adverse effects upon ingestion (except for occasional constipation) (ATSDR 2007, WHO 2001). However, some of the more soluble forms of barium, such as barium acetate, barium chloride, barium oxide, barium hydroxide, and barium carbonate can exhibit adverse effects after ingestion (ATSDR 2007).

Benzene
Benzene, also known as benzol, is a colorless liquid with a sweet odor. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable. Most people can begin to smell benzene in air at approximately 60 parts of benzene per million parts of air (ppm) and recognize it as benzene at 100 ppm. Most people can begin to taste benzene in water at 500 to 4,500 µg/L (0.5– 4.5 mg/L). One milligram per liter (1.0 mg/L) is approximately equal to one drop in 40 gallons. Benzene is found in air, water, and soil. Benzene comes from both industrial and natural sources. Because of its wide use, benzene ranks in the top 20 in production volume for chemicals produced in the United States. Natural sources of benzene, which include gas emissions from volcanoes and forest fires, also contribute to the presence of benzene in the environment. Benzene is also present in crude oil and gasoline and cigarette smoke (ATSDR 2007b).

Bromide
This discussion applies specifically to inorganic bromide ion and not to bromate or other organic bromine compounds, for which individual health-based guideline values have been developed. Bromide (Br^-) is the anion of the element bromine, which is a member of the common halogen element series that includes fluorine, chlorine, bromine and iodine. Bromide commonly exists as salts with sodium, potassium and other cations, which are usually very soluble in water. Bromide is commonly found in nature along with sodium chloride, owing to their similar physical and chemical properties, but in smaller quantities. Concentrations of bromide in fresh water typically range from trace amounts to about 500 µg/L (0.5 mg/L) (WHO 2010).

Bromide has been detected in hydraulic fracturing flowback (Hayes 2009). The typical daily dietary intake of bromide in the United States of America is 2–8 mg from grains, nuts and fish. Bromide and chloride are always present in body fluids in animals in steady state at levels dependent upon intake, and both are excreted readily. Increased chloride intake will increase the excretion of bromide (WHO 2010).

Iron
Iron is a mineral that is naturally present in many foods, added to some food products, and available as a dietary supplement. Iron is an essential component of hemoglobin, an erythrocyte protein that transfers oxygen from the lungs to the tissues. As a component of myoglobin, a protein that provides oxygen to muscles, iron supports metabolism. Iron is also necessary for growth, development, normal cellular functioning, and synthesis of some hormones and connective tissue (NIH 2018). Iron in residential well water is typically under 300 µg/L (WHO 1996). The recommended adequate intakes (AI) for iron are: 8 mg/day for men and post-menopausal women, 18 mg/day for pre-menopausal women, 10 mg/day for adolescents and 27 mg/day for pregnant women. The upper acceptable daily intake (UL) is 45 mg/day (IOM 2001).

IOM. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. The National Academies Press. Online at https://www.nap.edu/read/10026/chapter/1#ii

National Institutes of Health (NIH). 2018. Iron Fact Sheet for Health Professionals. March 2. Available at: https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/

WHO. 1996. Iron in Drinking Water. Originally published in Guidelines for drinking-water quality, 2nd ed. Vol. 2. Health criteria and other supporting information. World Health Organization, Geneva, 1996. Available online at: http://www.who.int/water_sanitation_health/dwq/chemicals/iron.pdf

Isopropanol

Isopropanol is a clear, colorless liquid with a fruity odor and a mild bitter taste. Most commonly found domestically as rubbing alcohol, isopropanol is also found in numerous household and commercial products including cleaners, disinfectants, antifreezes, cosmetics, solvents, inks, and pharmaceuticals (Slaughter et al., 2014). The majority of isopropanol exposures are unintentional and occur in children less than 6 years of age. Although isopropanol poisoning appears to be a reasonably common occurrence, deaths are rare (Slaughter et al., 2014). Slaughter et al. (2014) note that severe isopropanol poisoning results in central nervous system and respiratory depression, and circulatory collapse; however, patients usually make a full recovery provided they receive prompt supportive care.

Isopropanol is listed as the primary toxic component on the material safety data sheet (MSDS) for the product F-485 (Bachman 2003). F-485 is the chemical mixture injected at the Reese Hollow 118 well pad. JKLM Energy reported using approximately 98 gallons of F-485 at the Reese Hollow 118 well pad, with 30 of those gallons returning to the surface and collected for proper disposal. Approximately 68 gallons of F-485 were injected and not recovered. Isopropanol is reported to be 10% by volume in the F-485 product injected into the ground at the well pad. Based on the maximum Coudersport residential well isopropanol detection of 15 mg/L (RW#1), the maximum isopropanol exposure concentrations from drinking water are expected to be lower than those reported in the examples discussed by Slaughter et al. (2014). Severe poisoning, such as those which occur from ingesting isopropanol consumer products (e.g., rubbing alcohol, which typically contains 70% isopropanol in water), as discussed above, is not expected to have occurred from Coudersport groundwater contamination. However, it is not certain whether transient health effects, such as nausea and gastro-intestinal upset are possible from the brief exposure encountered at the residence (RW#1).

Bachmann Drilling and Production Specialties, Inc. 2003. F-485 Material Safety Data Sheet. Accessed online March 30, 3017: http://carbonwaters.org/wp-content/uploads/2015/09/F-485.pdf

Slaughter, R.J., Mason, R.W., Beasley, D.M., Vale, J.A., Schep, L.J. 2014. Isopropanol poisoning. Clinical Toxicology. (Phila). 52(5):470-8. May 9. doi: 10.3109/15563650.2014.914527.

Lead

Lead is a heavy, low-temperature-melting, bluish-gray metal that occurs naturally in the Earth's crust. However, it is rarely found naturally as a metal. It is usually found combined with two or more other elements to form lead compounds. Lead occurs naturally in the environment. However, most of the high levels found throughout the environment come from human activities.

Environmental levels of lead have increased more than 1,000-fold over the past three centuries as a result of human activity.

Metallic lead is resistant to corrosion (i.e., not easily attacked by air or water). When exposed to air or water, thin films of lead compounds are formed that protect the metal from further attack. Lead is easily molded and shaped. Lead can be combined with other metals to form alloys. Lead and lead alloys are commonly found in pipes, storage batteries, weights, shot and ammunition, cable covers, and sheets used to shield us from radiation. The largest use for lead is in storage batteries in cars and other vehicles.

Lithium

The average daily lithium intake of a 70-kg American adult is between 0.65 and 3.1 milligrams per day (Schrauzer 2002). Major dietary sources of lithium are grains and vegetables (0.5–3.4mg Li/kg food), dairy products (0.50mg Li/kg food) and meat (0.012 mg Li/kg food) (Weiner, 1991). Lithium concentrations in groundwater are understood to be higher where lithium-rich brines and minerals occur (Aral and Vecchio-Sadu 2008). Lithium is not expected to bioaccumulate and its human and environmental toxicity are considered to be low. ATSDR evaluated available toxicological literature and concluded that acute exposures (less than 2 weeks) to lithium in drinking water at concentrations less than 1,500 μg/L are not expected to result in adverse health effects (ATSDR 2012). Doses of lithium (up to 10 mg/L in serum) are given to patients with bipolar disorder; at 10 mg/L of blood, a person is mildly lithium poisoned (Aral and Vecchio-Sadu 2008). At 15 mg/L they experience confusion and speech impairment, and at 20 mg/L Li there is a risk of death.

A wide range of estimates for daily dietary intake of lithium are reported. Some authors report estimated doses for the average daily dietary intake of lithium ranging from 0.24 to 1.5 μg/kg/day (0.00024 to 0.0015 mg/kg/day), while another reports an average of up to 33 to 80 μg/kg/day (0.033 to 0.080 mg/kg/day) (EPA 2008). Literature reports lithium salts have been used therapeutically at adult doses varying between 900,000 μg /day (900 mg/day) to 1,800,000 μg/day (1,800 mg/day). The pharmacological dose is selected for individual patients to achieve therapeutic serum concentrations ranging from 0.6 to 1.4 millimoles per liter (mmol/L). Serum concentrations between 0.8 and 1.0 mmol/L are generally accepted as the optimally therapeutic range. A 900,000 μg (900 mg) dose of lithium carbonate medication contains 170,000 μg (170 mg) lithium; therefore, 170,000 μg (170 mg) of lithium for a 70-kg adult equates to roughly 2,500 μg/kg/day (2.5 mg/kg/day). It should be noted that the therapeutic range for lithium treatment has been shown to produce adverse health effects for some of the population.

Elevated lithium levels were consistently detected in a hydraulic fracturing flowback study of Marcellus shale completions ranging from non-detect to 153,000 μg/L (153 mg/L) with a median concentration in flowback of 43,700 μg/L (43.7 mg/L) (Hayes 2009).

Manganese

Manganese is an essential mineral: a nutrient your body needs to function, but cannot produce on its own. However, regularly breathing in high concentrations of manganese is known to cause irreversible neurological effects similar to Parkinson's disease, and studies have suggested the potential for similar toxicity through drinking water exposure to manganese.

Children are especially susceptible to any negative neurotoxic effects of manganese. Compared to adults, infants and children have higher intestinal absorption of manganese, as well as lower biliary excretion of manganese. Studies in children have suggested that extremely high levels of manganese exposure may produce undesirable effects on brain development, including changes in behavior and decreases in the ability to learn and remember. In some cases, these same manganese exposure levels have been suspected of causing severe symptoms of manganism disease (including difficulty with speech and walking). We do not know for certain that these changes were caused by manganese alone. We do not know if these changes are temporary or permanent. We do not know whether children are more sensitive than adults to the effects of manganese, but there is some indication from experiments in laboratory animals that they may be.

Concentrations of manganese in groundwater vary depending on the local geology and other local/regional activities and issues. The United States Geological Survey has reported manganese concentrations ranging from less than 0.13 µg/L to 1,710 µg/L (0.00013 - 1.7 mg/L) in a survey of 20 domestic wells in Sullivan County, Pennsylvania (Sloto 2013). Similarly, Chester County, Pennsylvania reports manganese concentrations in 360 wells ranging from less than 1 µg/L to 3,200 µg/L (0.001 - 3.2 mg/L) (Ludlow and Loper 2013). The EPA drinking water health advisory (HA) for manganese is 300 µg/L (0.3 mg/L) (EPA 2004).

The HA is based on the EPA reference dose (RfD) of 0.14 milligrams of manganese per kilogram body weight per day (mg/kg/day) with modifying factors to account for uncertainties about the effects of manganese exposure from water versus food and to account for intake from both food and drinking water. The reference dose was developed from population dietary data and represents a general intake that is not likely to result in any adverse effects. For most people, the greatest exposure to manganese is from food (EPA 2004).

The Food and Nutrition Board of the National Research Council has established Estimated Safe and Adequate Daily Dietary Intake Levels (ESADDI) for manganese that range from 0.3 mg/day for infants to 5 mg/day for adults (IOM 2000). IOM has a tolerable upper intake level (UL) of 2-3 mg/day for 1-8 years old children; 6 mg/day for 9-13 years old children; 9 mg/day for children under 18 years of age; and, 11 mg/day for adults (Table C1). ULs include exposures to manganese from all sources, including food, water, and supplements. For most people, food is the primary source of manganese exposure. The EPA HA and ESADDI values are used for assessing chronic manganese exposures to children and adults.

Concentrations of manganese exceeding 50 µg/L can give drinking water an unpleasant taste and appearance, and can result in black staining of household fixtures (EPA 2017). The EPA SMCL for manganese is set at 50 µg/L to avoid these adverse taste and staining problems. Water from wells with manganese exceeding 50 µg/L may not be palatable, but if levels remain below 300 µg/L, adverse health effects from these exposures are not expected to occur.

Table C1
Food and Nutrition Board of the National Research Council's Estimated Safe and Adequate Daily Dietary Intake Levels (ESADDIs) for Manganese

Age Range	Estimated Safe and Adequate Daily Dietary Intake Level
Birth to 6 months	0.3 to 0.6 mg/day
1 to 3 years	1.0 to 1.5 mg/day
4 to 6 years	1.0 to 2.0 mg/day
7 to 10 years	1.0 to 2.0 mg/day
Adolescents older than 11 years and Adults	2.0 to 5.0 mg/day

Source: IOM, 2001; Notes: mg/day = milligrams manganese per day

Sodium

Sodium is an essential element used in the body for proper muscle and nerve function. High sodium intake can affect blood pressure, and some people with high blood pressure or kidney problems may be on sodium-restricted diets. EPA has a drinking water advisory of 20,000 µg/L for people on a sodium-restricted diet (EPA 2012). The tolerable upper intake level for sodium, the highest level of sodium that can be consumed daily that is unlikely to be harmful for healthy people, ranges from 1,500 milligrams per day (mg/day) for children to 2,300 mg/day for adults (EPA 2012).

Appendix D

Shower Model Information

Three residential drinking water wells in the Coudersport area were contaminated with isopropanol; only one well, RW#1, exceeded health-based screening values. The isopropanol-contaminated water was used for household purposes, including showering. Volatile organic compounds (VOCs) such as isopropanol can escape, or volatilize, from water used in the home. Breathing in (inhaling) the isopropanol vapors in air that occurs when using contaminated water for showering can be a significant source of exposure. Because inhalation and, to a lesser extent, skin absorption of isopropanol during showering can be significant, ATSDR evaluated isopropanol exposures during showering at the residence using RW#1 well water. To evaluate this exposure pathway (inhalation during showering), ATSDR computed both a central tendency, or typical, exposure scenario, and a worst case, or reasonable maximum, exposure scenario (RME), to identify concentrations for comparison with the California OEHHA health-based screening value of 3,200 $\mu g/m^3$. There are several steps, discussed below, in estimating this equivalent 1-hour air concentration.

Note: We recognize that very young children (>1 year) are likely to take more baths than showers, therefore, we did not estimate showering exposures for this age group. While we recognize that bathing would not likely result in exposures as great as showering because showering has a high flow rate and more volatilization of VOCs, we still likely underestimated the total exposures to very young children. ATSDR used several equations and exposure assumptions to estimate how much isopropanol a person would inhale while showering.

Table D1. Reasonable Maximum Exposure Assumptions for Inhalation of Isopropanol while Showering

Age group	95th percentile shower time (minutes)	95th percentile bathroom stay after shower (minutes)	95th percentile short-term breathing rates while showering (m^3/min)	95th percentile long-term breathing rates (m^3/day)
1 to <2 years	30	20	0.01600	12.800
2 to <6 years	30	20	0.01450	13.775
6 to <11 years	30	20	0.01500	16.600
11 to <16 years	30	20	0.01700	21.900
16 to <21 years	30	20	0.01600	24.600
21 to <65 years	30	20	0.01620	20.660
> 65 years	30	20	0.01533	17.133
Pregnant women (16 to 45 years)	30	20	0.02000	28.800
Nursing women (16-45 years)	30	20	0.01903	27.400
Reasonable maximum exposure (RME) shower time and bathroom is 30 and 20 minutes, respectively. RME calculation also includes 9th percentiles for breathing rates. Inputs from Table 6-32: Time spent (minutes) Showering and in Shower Room Immediately After Showering, EPA Exposure Factors Handbook (2011) Table 6-2: Recommended Short-Term Exposure Values for Inhalation (males and females combined), Light Intensity, EPA Exposure Factors Handbook (2011).				

.

Table D2. Central Tendency Exposure Assumptions for Inhalation of Isopropanol while Showering

Age Group	Average Shower time (minutes)	Average Bathroom Stay after Shower (minutes)	Average Short-term Breathing Rates While Showering (m3/min)	Average Long-term Breathing Rates (m3/day)
1 to <2 years	8	5	0.0120	8.0
2 to <6 years	8	5	0.0113	9.6
6 to <11 years	8	5	0.0110	12.0
11 to <16 years	8	5	0.0130	15.2
16 to <21 years	8	5	0.0120	16.3
21 to <65 years	8	5	0.0124	15.5
65+ years	8	5	0.0120	13.1
Pregnant Women (16 to 45 years)	8	5	0.0151	21.7
Nursing women (16-45 years)	8	5	0.01590	22.9
Average shower time and bathroom stay after shower derived using professional judgment with input from Table 6-32: Time spent (minutes) Showering and in Shower Room Immediately After Showering, EPA Exposure Factors Handbook (2011) Table 6-2: Recommended Short-Term Exposure Values for Inhalation (males and females combined), Light Intensity, EPA Exposure Factors Handbook (2011) Average represents the mean (50th percentile) value				

EXAMPLE OF INHALATION CALCULATION(S):

Use the equations below and values in Table B1 to calculate the amount of isopropanol inhaled while showering

Example using: Adult (21+ years old) showering for 30 minutes with maximum concentration of isopropanol (15,000 µg/L) in water

Estimating the inhalation exposure dose is a 2-step process:

1. **Calculate the isopropanol concentration in the bathroom**
2. **Calculate the amount of isopropanol inhaled**

ATSDR used a model developed by Andelman [1990] to estimate the isopropanol concentration occurring in the bathroom as a result of showering for 30 minutes and 20 minutes in bathroom following a shower (worst-case scenario). The equation for reasonable maximum (RME) and central tendency (CTE) of exposure is as follows:

Equation for concentration of isopropanol in air:

$$C_a = \frac{k \times F_w \times T_s \times C_w \times CF}{V_a}$$

Ca = air concentration in bathroom/shower, in milligrams per cubic meter (mg/m^3),
k = volatile mass transfer coefficient, unitless (0.3 used for isopropanol)
Fw = flow rate of water through shower, in liters per min, L/min (default is 8 L/min)
Ts = time shower is running, in minutes (See Table B1 – 30 minutes total is 95th percentile for shower time; 8 minutes is median estimated shower time)
Cw = VOC concentration in water, in milligrams per liter (15 mg/L used as maximum)
CF = conversion f actor (1,000)
Va = bathroom air volume, in liters, L (default is 10,000 L)

Step 1. Calculate the concentration of isopropanol in the bathroom for median and 95th percentile time durations

RME concentration of isopropanol in bathroom

$$\frac{0.3 \times 8 \text{ L/min} \times 30 \text{ min} \times 15 \text{ mg/L} \times 1000 \text{ L/m}^3}{10{,}000 \text{ L}} = \mathbf{108\ mg/m^3}$$

CTE concentration of isopropanol in bathroom

$$\frac{0.3 \times 8 \text{ L/min} \times 8 \text{ min} \times 15 \text{ mg/L} \times 1000 \text{ L/m}^3}{10{,}000 \text{ L}} = \mathbf{29\ mg/m^3}$$

The isopropanol concentration in air will be breathed in during the shower and during any time stayed in the bathroom after the shower. Both the median and reasonable maximum exposure values were calculated in the formula boxes above.

To calculate a **time-weighted-average concentration** to compare to the California OEHHA one-hour health-based screening value of 3.2 mg/L, the RME and CTE exposure concentrations are adjusted to a one-hour exposure, as follows:

RME one-hour exposure concentration:

$$\frac{108 \text{ mg/L} \times 50 \text{ minutes}}{60 \text{ minutes}} = 90 \text{ mg/L}$$

CTE one-hour exposure concentration:

$$\frac{29 \text{ mg/L} \times 13 \text{ minutes}}{60 \text{ minutes}} = 6.3 \text{ mg/L}$$

Using central tendency and reasonable maximum exposure assumptions for calculating typical and worst-case isopropanol exposures while showering, respectively, ATSDR concludes that isopropanol inhalation exposures exceed the acute, one-hour screening value and may result in adverse health effects for some individuals.

Appendix E

Community Concerns and Responses

The petitioner provided electronic files to ATSDR describing their environmental and health concerns. In these files, the petitioner expressed specific concerns. These concerns are identified below followed by ATSDR responses:

Are there impacts to public water supplies, including any impacts to the recharge zone of two public water supplies, the Borough of Coudersport and the Charles Cole Memorial Hospital? Is the water in the aquifer potable; including after JKLM Reese Hollow 118 well pad activities?

Response: The data made available to ATSDR includes many rounds of sampling data for both public supply wells, including the Borough of Coudersport and Charles Cole Memorial Hospital source wells. Data from these public water supply wells are included and evaluated in this health consultation.

Although this document cannot be used to evaluate the potability of an entire aquifer, ATSDR's evaluation of the sampling and analyses of over 100 groundwater sources in the impacted area indicates the aquifer(s) accessed in the Coudersport area for drinking water continues to provide potable drinking water. Some of the residential wells have drinking water quality issues (e.g., bacterial contamination, metals, salts) and steps should be taken to address these issues. For additional information, refer to the conclusions and recommendations within this document.

The use of F-485, which is a "surfactant containing 10% isopropanol. The composition of the remaining 90 percent is 'proprietary'." Should we be concerned about exposures to these proprietary chemicals?

Response: It is accurate that the proprietary components of F-485 are not known to ATSDR. However, it is important to note that PADEP required well sampling and analyses for many more chemicals than those specifically identified as site-related chemicals. It is possible that proprietary chemicals may not have been identified in sample results. However, more than 200 chemical and water quality analyses were performed on multiple samples from many of wells that may have been impacted.

The use of Rock Oil and the use of other chemicals not reported by JKLM. Should we be concerned about exposures to these other chemicals?

Response: ATSDR has met with and discussed the JKLM event with PADEP oil and gas program staff, who have shared their available information with ATSDR. Detections of BTEX (benzene, toluene, ethylbenzene, and xylene) in groundwater samples suggest Rock Oil components were present in the groundwater following its improper use at the Reese Hollow 118 well pad. PADEP has indicated that Rock Oil and F-485 were the chemicals used improperly at the well pad and has indicated that additional chemicals were not injected at the well pad.

Why the positive chemical detections by PADEP when JKLM sampling indicated the chemical was not present (based on "non-detect" or "ND" in the laboratory results)?

Response: The PADEP sample analyses had lower limits of detection (LOD) than those employed by JKLM. While both the JKLM-contracted and PADEP laboratory analyses had LODs that were below regulatory standards, PADEP's were even lower than JKLM's. Therefore, while JKLM provided accurate laboratory analytical reports, PADEP had more sensitive laboratory analyses and was able to report the presence of chemicals below those that could be detected by JKLM's contracted laboratory.

What about the presence of unregulated chemicals at trace concentrations in the aquifer due to use of water hauled in a "frack waste" tanker truck; and, the risks posed by exposure to components of the injected fluids that are not regulated by the Safe Drinking Water Act (SDWA).

Response: As noted in the response to previous question, PADEP required well sampling and analyses for many more chemicals than those specifically identified as site-related chemicals. More than 200 chemical and water quality analyses were performed on water samples for this investigation. Many of these chemicals that were tested for are not regulated by the SDWA. However, it is possible that some chemicals related to natural gas activities were not included in the analyses, and that would represent a limitation of this evaluation.

ATSDR is a non-regulatory, federal public health agency. Regulatory programs and policies are best explained by those agencies responsible for enforcing regulations. In the case of natural gas drilling in Pennsylvania, the Pennsylvania Department of Environmental Protection (PADEP) and the U.S. Environmental Protection Agency have authority to take and order actions that protect public health and the environment.