Health Consultation

Evaluation of Radionuclides in Air and Water Near the White Mesa

URANIUM MILL WHITE MESA

WHITE MESA, SAN JUAN COUNTY, UTAH

EPA Facility Registry ID: 110000879425

JUNE 02, 2023

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

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR 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 which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By

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Abbreviations

ATSDR	Agency for Toxic Substances and Disease Registry
CVs	Comparison Values
DOE	United States Department of Energy
EPC	Exposure point concentration
hr	Hour
ICRP	International Commission on Radiological Protection
min	Minute
mrem	Millirem
m^3	Cubic Meter
MRL	Minimal Risk Level
NRC	United States Nuclear Regulatory Commission
PET	Positron Emission Tomography
pCi	Picocurie
USGS	United States Geological Survey

Summary

On February 04, 2019, the Agency for Toxic Substances and Disease Registry (ATSDR) received a petition to assist in evaluating public health implications of environmental contaminants associated with the White Mesa Uranium Mill, San Juan County, Utah [1]. Milling activities concentrate naturally occurring radiological materials in generated waste known as tailings. The White Mesa Uranium Mill stores generated waste on mill property in storage piles and settling ponds. The purpose of this health consultation is to address the Ute Mountain Ute Tribe's concerns raised in their 2019 petition letter. This entails providing health hazard evaluation related to available radiological environmental sampling results and the potential for exposures to residents of White Mesa in San Juan County, Utah.

The Ute Mountain Ute Tribe formally petitioned ATSDR for assistance in evaluating the radiological and chemical data. The Ute Mountain Ute Tribe is particularly interested in the following questions: 1) if exposures could occur from inhalation of suspended radiological waste products and if onsite settling ponds could impact aquifers used for drinking water; 2) if radon from the mill and settling ponds is impacting people at the Mill fence line and at residences nearby; 3) if soil and vegetation in the public lands surrounding the Mill poses a health hazard to people; and 4) if springs and seeps pose a health hazard to people.

This health consultation describes the evaluation of radiologic data collected by the Ute Mountain Ute Tribe for their drinking water and outdoor air. It also makes recommendations for further environmental sampling. ATSDR does not have radiological data to evaluate radon, soil, vegetation, or springs and seeps. Non-radiological (chemical) data will be addressed in a future health consultation.

Conclusions of ATSDR's Evaluation

Based on the evaluation and specific assumptions detailed in this report, we reached the following conclusions.

Conclusion 1

Children and adults who drink the water from the Ute Mountain Ute Tribe public water system are unlikely to be harmed from radiological contaminants.

Basis for Conclusion

Drinking water sampling data provided by the Ute Mountain Ute Tribe are below the U.S. Environmental Protection Agency's (EPA's) maximum contaminant level for all radiological contaminants. This means radiological doses are less than ATSDR's minimal risk level.

Next Steps

ATSDR recommends the Ute Mountain Ute Tribe continue to monitor their public water drinking supplies in accordance with all applicable U.S. EPA regulations.

Conclusion 2

Children and adults living in White Mesa are unlikely to be harmed from breathing radiological contaminants in the air. ATSDR cannot evaluate other areas of concern.

Basis for Conclusion

- To evaluate possible effects from air exposures, ATSDR estimated the radiation exposure and resulting dose for residents of various age groups who breathed unfiltered air. We assumed they were always exposed to the highest reported concentrations of contaminants. Estimated annual radiological doses calculated from Ute Mountain Ute Tribe air sampling data taken within the White Mesa Community are below ATSDRs minimal risk level for radiation, which means that observable adverse health effects are unlikely.
- ATSDR does not have air sampling data to evaluate other areas of concern.

Next Steps

ATSDR recommends that Ute Mountain Ute Tribe collect air samples in areas of concern closer to the uranium mill property boundary and during periods of elevated mill activity. These data can be used to characterize radiological material at the sample location. ATSDR also recommends that the Ute Mountain Ute Tribe consult with either ATSDR or U.S. EPA to determine the need and locations of air sampling that would be indicative of background air concentrations.

Conclusion 3

ATSDR cannot evaluate if radon emissions from the mill could impact bordering properties or residents.

Basis for Conclusion

ATSDR does not have radon sampling data for the locations of interest to the Ute Mountain Ute Tribe.

Next Steps

ATSDR recommends that the Ute Mountain Ute Tribe collect radon samples in areas of interest to the Ute Mountain Ute Tribe.

Conclusion 4

ATSDR cannot evaluate if soil and vegetation present a radiation hazard.

Basis for Conclusion

ATSDR does not have radiological soil and vegetation sampling data to evaluate.

Next Steps

ATSDR recommends that the Ute Mountain Ute Tribe collect soil samples in locations of interest.

Conclusion 5

ATSDR cannot evaluate if seeps and springs present a radiation hazard.

Basis for Conclusion

ATSDR does not have radiological seeps and springs sampling data to evaluate.

Next Steps

ATSDR recommends that the Ute Mountain Ute Tribe collect water samples from seeps and springs.

NOTE

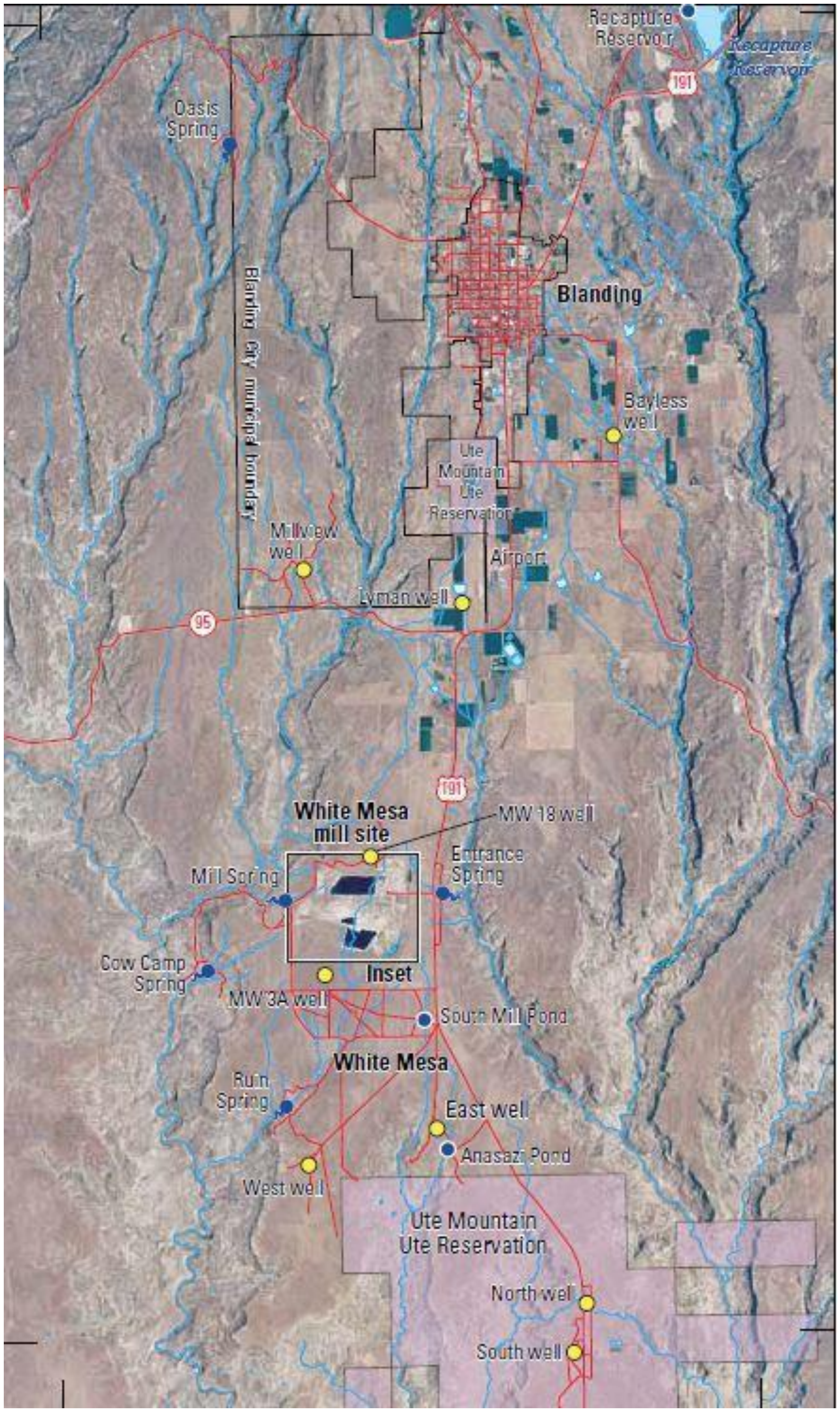
ATSDR's conclusions may change following availability of new environmental sampling data and relevant information.

Background

In 2011, the United States Geological Survey (USGS) published an assessment of the potential for materials from the White Mesa Uranium Mill (the Mill) in San Juan County, Utah, to migrate offsite. Concerns were raised by the USGS of potential air and water contamination via airborne dust and leakage from waste tailing ponds to shallow aquifers beneath the mill.

In 2018, EPA Region 8 and the Ute Mountain Ute Tribe contacted Region 8 ATSDR with concerns about air sampling data provided by the Energy Fuels Company, owners of the White Mesa Uranium Mill. The data were being used to justify ongoing licensing and expansion of the Mill, which is adjacent to the White Mesa Reservation land of the Ute Mountain Ute Tribe. In February 2019, the Ute Mountain Ute Tribe petitioned the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate whether current and past environmental contamination from the Mill might impact the health of people living and working on Tribal Land [1]. The Mill is the only fully licensed and operating conventional uranium mill in the United States and is under license by the U.S. Nuclear Regulatory Commission. The Mill is adjacent to Ute Mountain Ute Tribe lands and located between two towns. Approximately seven miles north of the Mill is the town of Blanding, Utah. Four miles south of the Mill is the community of White Mesa, Utah. The Mill has operated since 1980, originally by Denison Mines and currently by Energy Fuels (See Figure 1).

Figure 1: Aerial photo showing White Mesa Mill in proximity to Blanding and the White Mesa Community in Utah [2].



Source: USGS, 2011 [2]

Purpose and Health Issues

This report evaluates whether activities related to uranium milling in San Juan County, Utah, have affected the health of White Mesa residents. Radiological waste generated from the uranium milling process is held on-site, in dry storage piles and liquid settling ponds.

Community members of the Ute Mountain Ute Tribe petitioned ATSDR to evaluate potential exposures of those residing in the White Mesa community in San Juan County, Utah. In response to community concerns, this health consultation focuses on potential radiological releases from uranium milling activity and the potential to affect public health.

In this report, ATSDR uses environmental sample data provided by the Ute Mountain Ute Tribe to estimate and evaluate exposure of children and adults to potential contaminants in drinking water and air. Specifically, individuals who reside near air sampling locations and individuals served by the Ute Mountain Ute Tribe public water system are included in this evaluation.

Exposure to radiation does not always result in harmful health effects. The type and severity of health effects that a person might experience depends on the radiation dose, which is based on the person's age at exposure, the exposure rate (how fast), the frequency (how often) and duration (how long), the route or pathway of exposure (breathing, eating, drinking, or skin contact), and the multiplicity of exposure (combination of contaminants). Once a person is exposed, characteristics such as age, sex, nutritional status, genetic factors, lifestyle, and health status influence how the contaminant is absorbed, distributed, metabolized, and excreted. An environmental concentration alone will not cause an adverse health outcome—the likelihood that adverse health outcomes will occur depends on site-specific conditions, individual lifestyle, and genetic factors that affect the route, magnitude, and duration of actual exposure.

ATSDR's Evaluation Process

As a first step in evaluating exposures, ATSDR screens the contaminant levels found in a particular medium (i.e., soil, air, or drinking water) against health-based comparison values (CVs). ATSDR develops CVs from available scientific literature concerning exposure, dose, and health effects. CVs represent radiation doses or chemical concentrations that are not expected to cause observable health effects based on results of animal or human studies, with safety factors built in. CVs are not thresholds for harmful health effects. Radiation doses and chemical media concentrations at or below the CVs can reasonably be considered safe. When a CV is exceeded, exposures will not necessarily produce harmful health effects. This screening process enables ATSDR to eliminate safely from further consideration contaminants not of health concern and to further evaluate potentially harmful contaminants. During the development of CVs for chemicals in the environment, ATSDR develops environmental media guidelines for exposure. In the case of radioactive materials in the environment, ATSDR approaches the exposures using a radiation dose-based methodology using internationally accepted radiation dose coefficients where appropriate. In addition, ATSDR uses radiological screening values developed through a peer review process.

ATSDR also establishes health guidelines such as minimal risk levels (MRLs). Because the MRL is an estimate of human exposure to a hazardous substance that is unlikely to have an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure, a dose exceeding the MRL does not mean that an adverse health effect will occur. The ATSDR MRL for ionizing radiation is

100 millirem per year (mrem/y) above ambient background levels [3]. The ATSDR MRL is not a regulatory level. However, for ionizing radiation, the MRL is the same value used by both the U.S. Department of Energy (DOE) and the U.S. Nuclear Regulatory Commission (NRC) to protect members of the public from general exposures produced by their licensees and facilities in the case of the DOE.

If the estimated radiation doses or chemical media concentrations at a site are above selected health-based CVs, ATSDR proceeds with a more in-depth health effects evaluation. ATSDR radiation safety scientists then determine whether the doses are large enough to trigger public health action to limit, eliminate, or study further any potentially harmful exposures. These specialists conduct a health effects evaluation by 1) examining site-specific exposure conditions for actual or likely exposures, 2) conducting a critical review of radiological, toxicological, medical, and epidemiological information in the scientific literature to ascertain the levels of significant human exposure, and 3) comparing an estimate of possible radiation doses or chemical doses to situations that have been associated with disease and injury. This health effects evaluation involves a balanced review and integration of site-related environmental data, site-specific exposure factors, and toxicological, radiological, epidemiological, medical, and health outcome data to help determine whether exposure to contaminant levels might result in harmful, observable health effects.

Appendices of this report present details of ATSDR's evaluation process.

- Appendix A explains how we used and evaluated community input on exposures at the site and developed reasonable exposure and intake assumptions used in exposure dose calculations.
- Appendix B describes the screening process for radiological contaminants. It includes a table showing contaminants selected for further evaluation.
- Appendix C describes how we calculated estimates of contaminant intake for the exposures evaluated.
- Appendix D details how we calculated radiological doses for the estimated exposures.

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[1] ATSDR calculates comparison values from minimal risk levels published by ATSDR (EMEGs), reference doses published by EPA (RMEGs), or cancer slope factors published by EPA (CREGs). Health assessment comparison values are maintained in ATSDR's PHAST (PHAST; version 3.0; ATSDR, Atlanta, GA)

Evaluation of Potential Community Exposure

Description of Potential Exposure Pathway

The community of White Mesa is approximately four miles south of the White Mesa Uranium Mill. People residing in White Mesa face potential exposure pathways from breathing suspended uranium processing waste. The public water supply comes from an aquifer that has the potential to be impacted from liquids held in settling ponds on mill property. If a settling pond were to leak, the residents could inadvertently ingest contaminated water. Elements of the exposure pathway are detailed in Appendix B. Table 1 below summarizes the pathway analysis.

The potential exposures evaluated in this report are the following:

Resident Exposure

Breathing in suspended uranium processing waste carried by wind from White Mesa Uranium Mill source piles

Drinking publicly supplied water in the White Mesa community that may be contaminated from uranium milling activity

Table 1. Pathway Analysis

	Public Water	**Air**
Source	Complete	Complete
Transport	Potential	Potential
Exposure Point	Potential	Potential
Exposure Route	Potential	Potential
Exposed population	Potential	Potential

Available Data and Information

ATSDR obtained and reviewed numerous reports, correspondence, and articles relating to the White Mesa Uranium Mill. ATSDR reviewed documents from Ute Mountain Ute Tribe, regulatory agencies, state, and federal governments.

Estimation of resident exposures were derived from the following information:

- Residential activity information provided by the Ute Mountain Ute Tribe, detailing frequency of activities for various age groups. This information was used as a basis for forming exposure assumptions. (Detailed in Appendix A)

- Environmental sampling data provided by the Ute Mountain Ute Tribe, including public water quality reports and air samples describing the levels of radiological material residents may encounter. These data were used to identify, where applicable, contaminants of concern and exposure point concentrations. (Detailed in Appendix B) Data relevant to community exposures included:

- White Mesa Community Drinking Water Quality Reports; 2014 through 2017 [5]
- Ute Mountain Ute Tribe air sampling data; 2013, 2018, and 2019 [6]

Exposure and Intake Assumptions for Residents

To estimate exposures for a given activity, ATSDR needs to use two kinds of assumptions in combination with data on contaminants in the environment. *Exposure assumptions* describe how often people do a certain activity and for how long. *Intake assumptions* are factors to estimate or calculate how much air or water from the environment a person might take into their body during the activity. Combining exposure and intake assumptions with concentrations of contaminants allows us to calculate the amount of contaminant taken into the body.

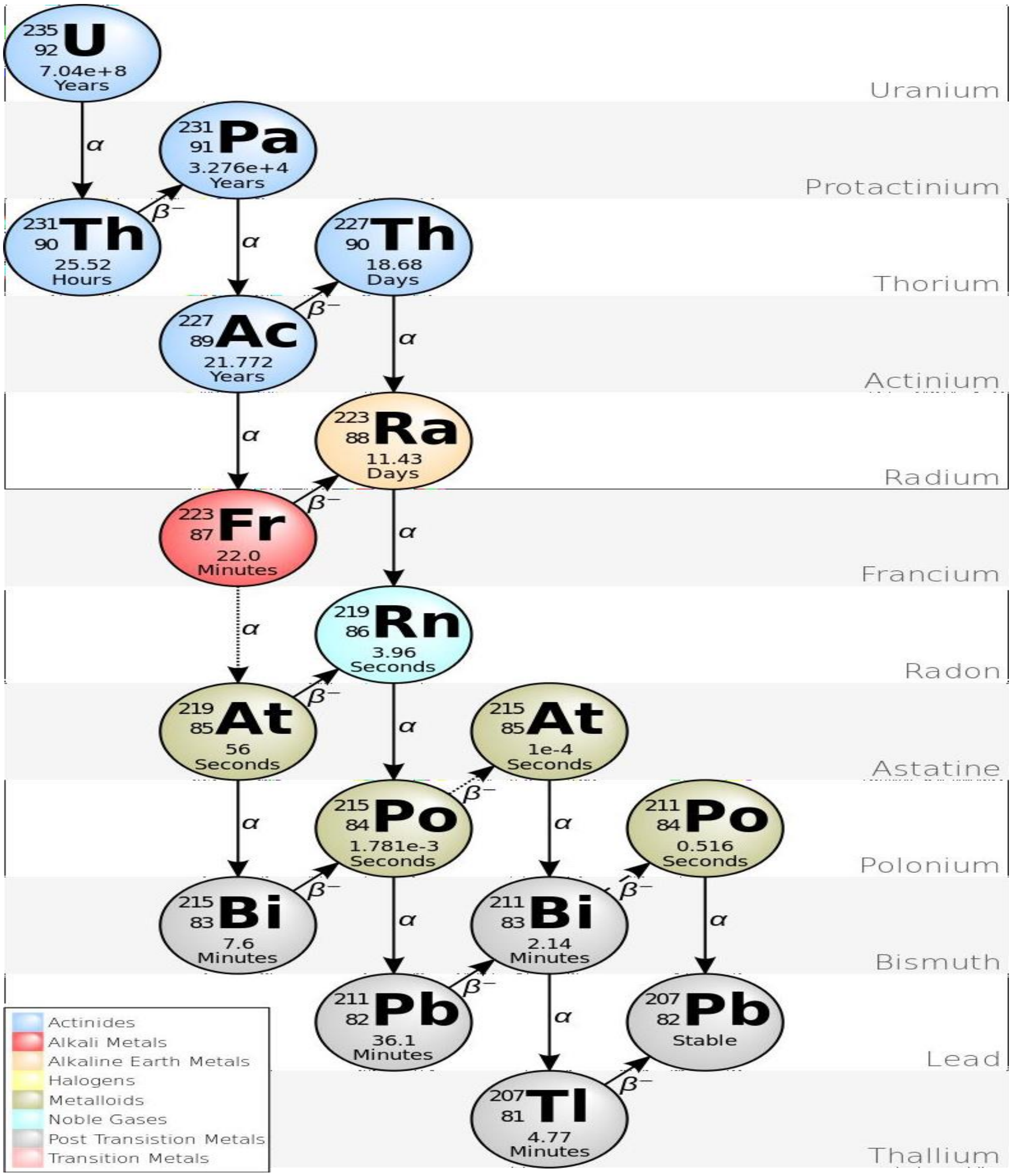
To develop exposure assumptions, the Ute Mountain Ute Tribe provided information about how often residents in White Mesa performed various activities. The information received can be found in Appendix A. Appendix A also contains an explanation of how ATSDR considered the input, along with how ATSDR developed the assumptions used in this assessment. Table 4 and Table 5 of Appendix A summarize the exposure assumptions used in ATSDR's evaluation.

For intake assumptions, ATSDR used the EPA Exposure Factors Handbook to describe how much air a resident could breathe in while living in White Mesa. [13] Table 5 of Appendix A summarizes the intake assumptions used in this evaluation.

Contaminants of Concern

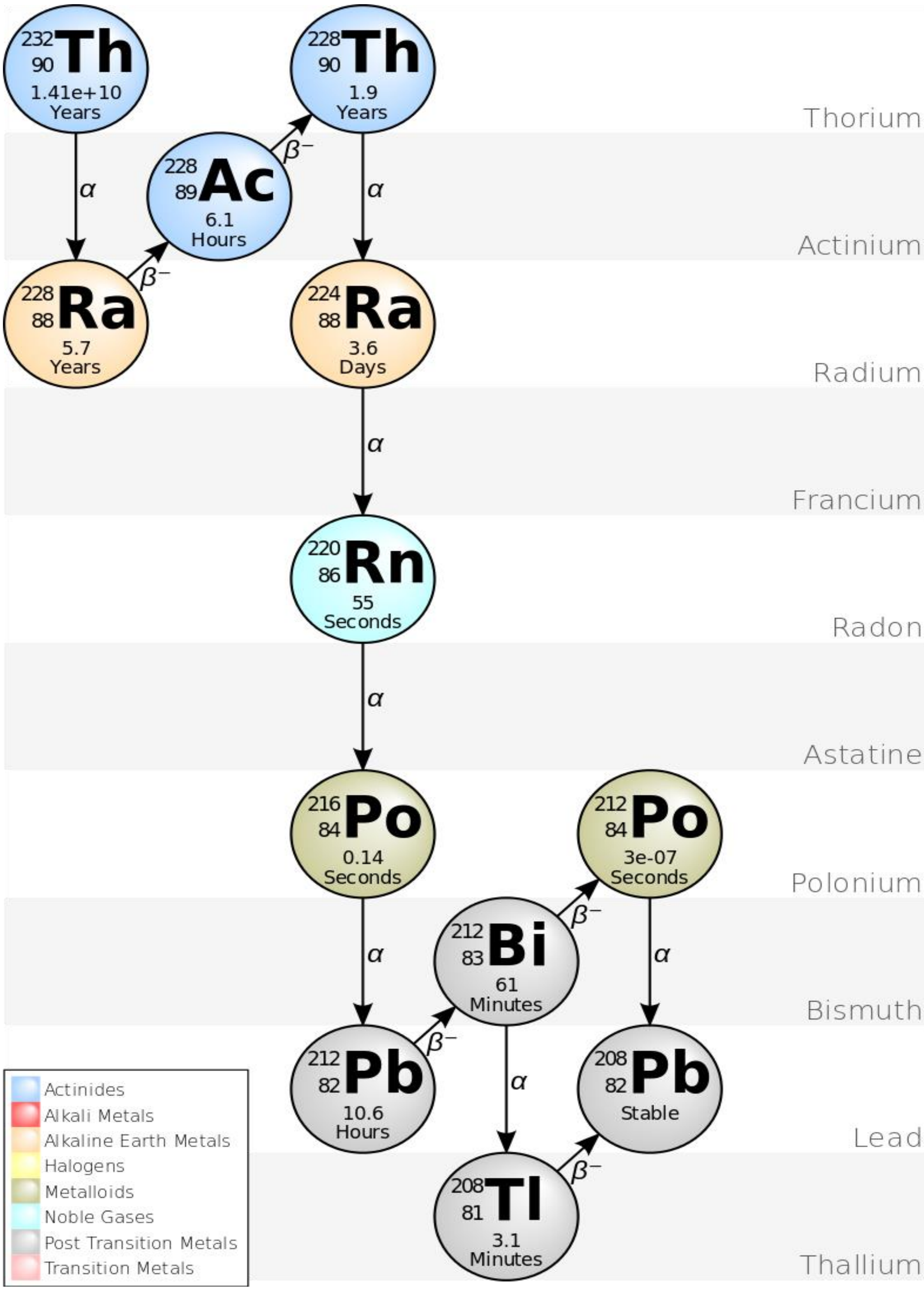
ATSDR reviewed the available water quality reports and air sampling data. For public supplied drinking water, determination of exposure point concentrations is unnecessary as the drinking water quality reports meet federal drinking water standards and was not evaluated further. Appendix B details ATSDR's screening of radiological contaminant data. ATSDR included isotopes in the actinium (U-235), uranium (U-238) and thorium (Th-232) decay series for this evaluation. These natural decay series are ubiquitous, but because of milling, concentrations of decay products can become elevated over background levels. Actinium, uranium, and thorium radioactive decay chains are depicted in Figure 2, Figure 3, and Figure 4 respectively.

Figure 2. Simplified Actinium Series



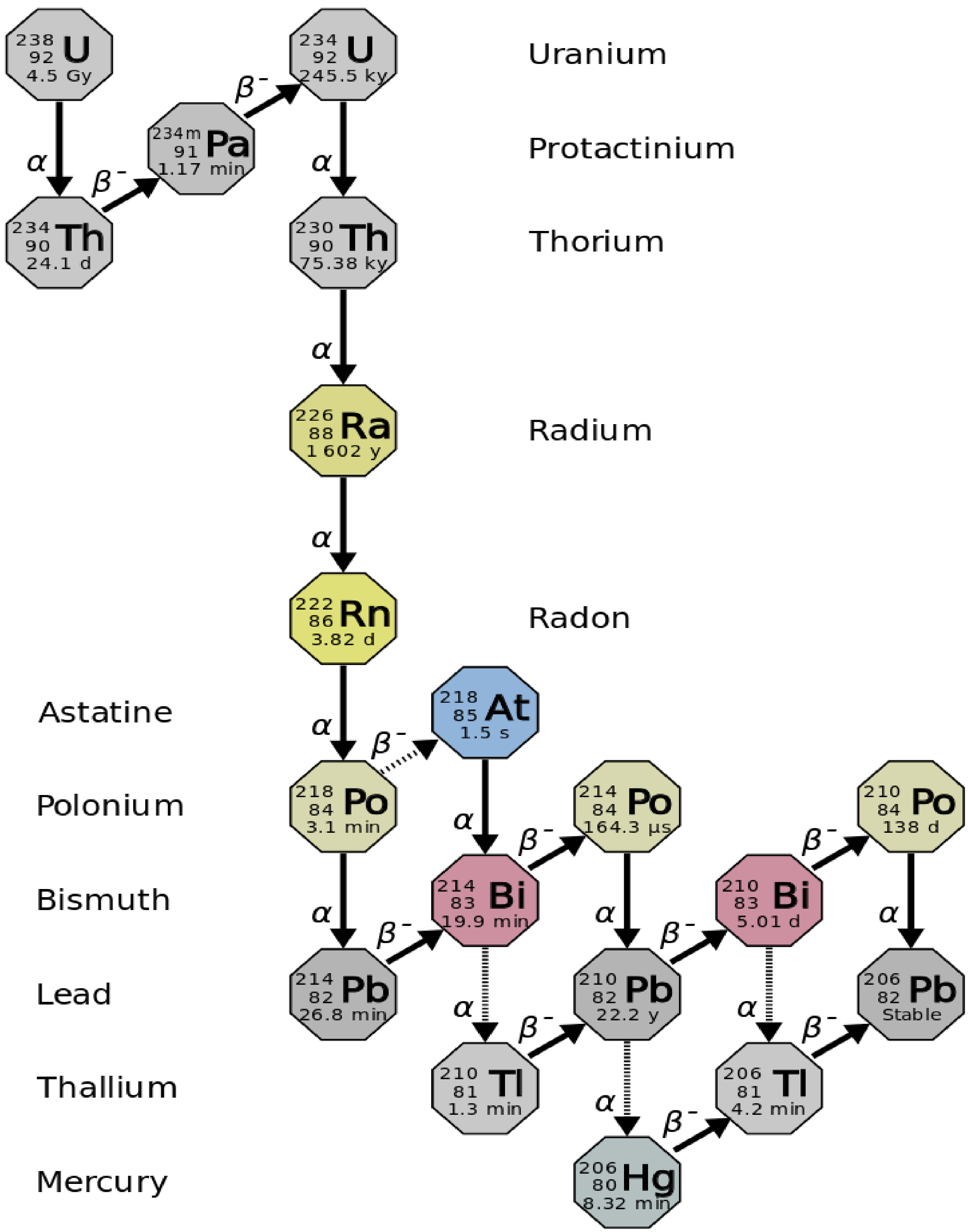
Simplified actinium series showing primary radioactive emissions—alpha (α) or beta (β)—released as each unstable atom transforms to a new decay product. Source: Wikimedia Commons, 2020 [7a]

Figure 3. Simplified Thorium Series



Simplified thorium series showing primary radioactive emissions—alpha (α) or beta (β)—released as each unstable atom transforms to a new decay product. Source: Wikimedia Commons, 2020 [7b]

Figure 4. Simplified Uranium Series



Simplified uranium series showing primary radioactive emissions—alpha (α) or beta (β)—released as each unstable atom transforms to a new decay product. Source: Wikimedia Commons, 2021 [7c]

Exposure Point Concentrations for Air and Drinking Water

Representative exposure point concentrations describing the highest levels of contaminant someone might be exposed to over time are needed to determine how much of each contaminant is taken in by residents. The Ute Mountain Ute Tribe provided maps showing air sampling locations as well as air sampling data. Figures 5 and 6 below show the location of Ute Mountain Ute Tribe air samplers. [8]

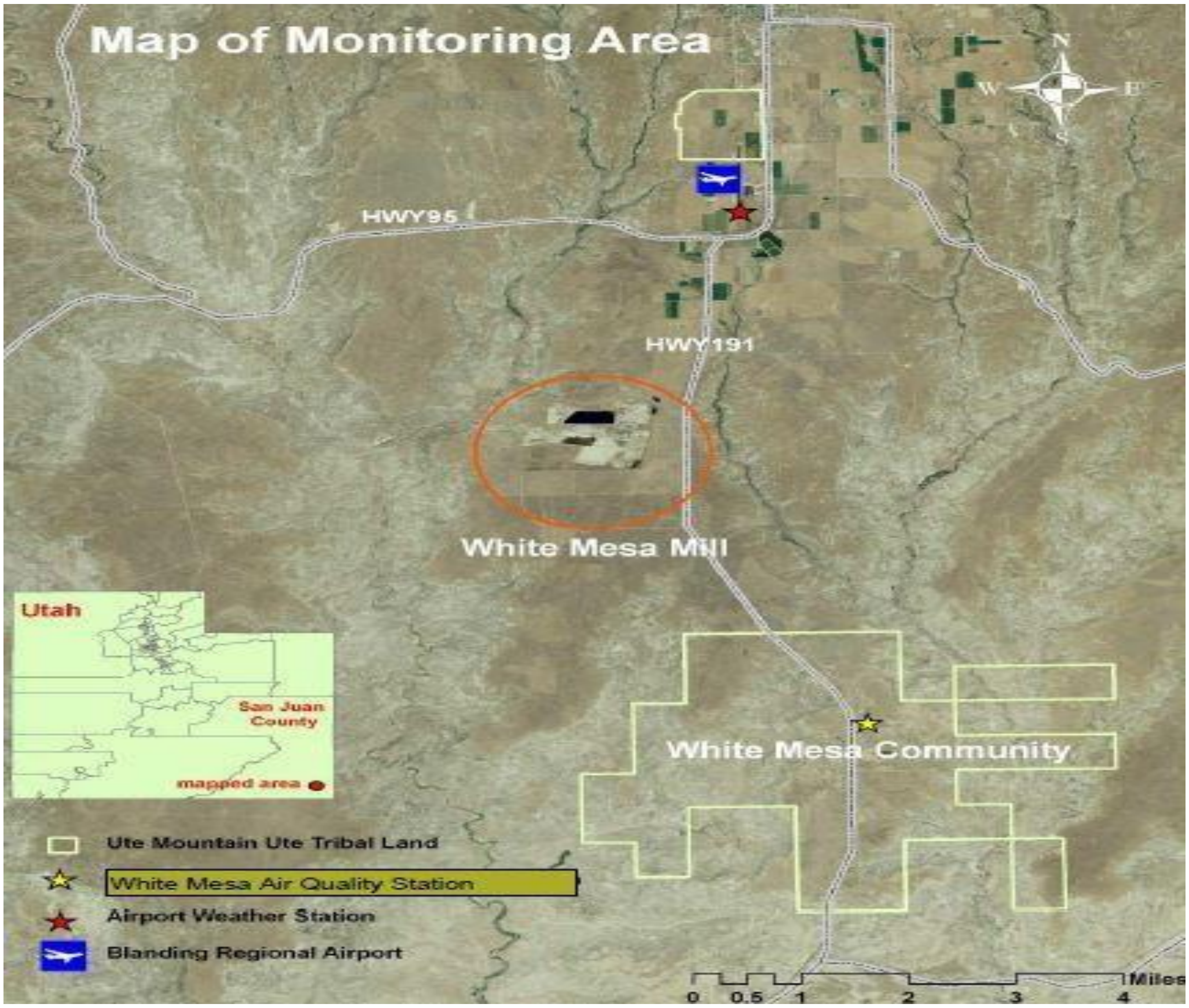
- For this health consultation, ATSDR conservatively used the highest reported isotope results for exposure point concentrations. Using the highest reported isotope concentration does not mean that the population received that exposure; using the highest reported value places a maximum value on the possible exposures. Appendix B describes the screening of contaminants for further evaluation. Table 2 below summarizes the range of radiological concentrations for air exposure. This report used the maximum reported values for exposure point concentrations.

- For public supplied drinking water, determination of exposure point concentrations is unnecessary as the drinking water quality reports meet federal drinking water standards.

Note

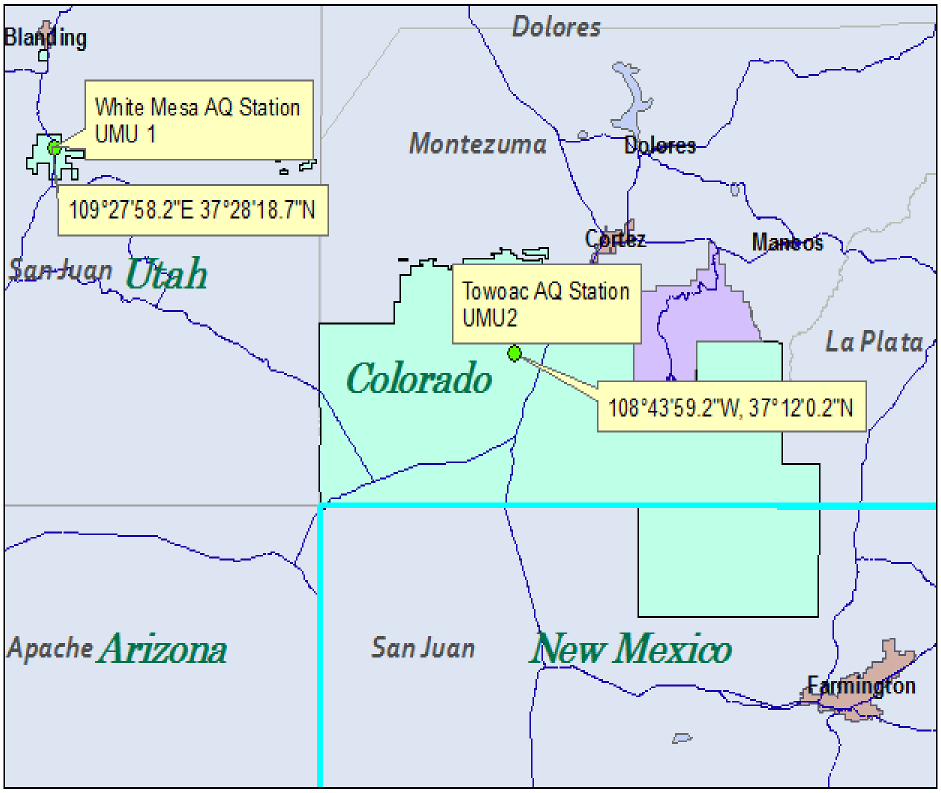
Air sampling at the Towoac air quality station (Towoac AQ Station) was not evaluated for this health consultation. The Towoac air quality station is approximately 50 miles from White Mesa and would not be representative of potential exposure at White Mesa.

Figure 5. Map Illustrating White Mesa Air Sampling Location [8]



Map provided by Ute Mountain Ute Tribe

Figure 6. Map Illustrating Towoac Air Sampling Location [8]



Map provided by Ute Mountain Ute Tribe

Table 2. Range of Radiological Concentrations for Air Exposure at White Mesa

Contaminant	Minimum (pCi/m3)*	Maximum (pCi/m^3)*
Lead-210	3.40E-03	6.80E-02
Polonium-210	1.23E-03	7.60E-02
Radium-226	2.70E-04	1.16E-03
Thorium-228	5.00E-05	2.30E-04
Thorium-230	7.90E-05	2.30E-04
Thorium-232	1.20E-05	1.59E-04
Uranium-234	4.30E-05	1.34E-03
Uranium-235	2.20E-05	1.60E-04
Uranium-238	3.50E-05	1.20E-03

* pCi/m^3 = picocuries per cubic meter
Concentrations are sample values without subtracting background.

Radiological Intake, Dose, and Risk

Intake of contaminants depends on the exposure point concentration combined with exposure and intake assumptions. Appendix C describes the equations used to calculate intake, along with tables of calculated intakes for the age groups used in this consultation.

We calculated intake in picocuries (pCi) annually. Age groups will have different intake rates due to biological differences. A younger individual will have less lung capacity than an older individual. Thus, older age groups have larger inhalation rates and larger intakes than younger age groups.

Intake itself does not completely determine the radiological dose. The radiological dose is a complicated function of what the radiological isotope is, how it enters the body (ingestion or inhalation), how much is taken up by the body, how much is eliminated or metabolized, what organs it is stored in, and how it changes as it radioactively decays. Organs in the body may also receive an external dose from isotopes outside the body. Each radioactive isotope has different characteristics. Appendix D gives more details about how we used coefficients derived by the International Commission on Radiological Protection (ICRP) to determine radiological doses from the exposures evaluated in this report [9]. ATSDR estimated doses from intakes using ICRP recommended default solubility dose coefficients for the radioisotopes of concern.

Increased Risk – What it Means

Risk can be defined as "the probability of any negative outcome"—for example, developing cancer after receiving a radiological dose to an organ. Numerically, risk is expressed as a probability between zero (absolute certainty the event will not occur) and one (absolute certainty that it will). For example, based on U.S. cancer rates, the lifetime risk of being diagnosed with any form of cancer in the general population is about 0.385, or about 3,850 out of every 10,000 people [10].

Environmental exposures to radiation typically involve doses far below those that cause cancers and other measurable health effects in exposed populations (such as Japanese atomic bomb survivors, radium dial painters, nuclear industry workers, or medical patients treated with radiation). However, most regulatory and advisory agencies assume every dose of radiation, no matter how small, incrementally increases the risk of developing cancer.

Results and Discussion

Effective Whole-Body Radiological Dose

ATSDR estimated effective whole-body radiological doses for residents of White Mesa. Effective whole-body dose is the basis for radiological standards such as worker limits and limits to the public. We calculated the annual effective whole-body dose for one year of exposure as shown in Appendix D, Tables 14 through 19, and summarized in Table 3 below. We can compare this annual dose to ATSDR's chronic minimal risk level (MRL) for ionizing radiation.

ATSDR's MRL is for a chronic whole-body dose from ionizing radiation of 100 mrem per year above normal background exposures, regardless of source. ATSDR applies the MRL to whole-body doses resulting from either internal exposure or external exposures [3]. Contributors to a person's normal background radiation dose include cosmic radiation, radon gas present in all air, rocks and soil containing natural radioactive elements, and natural radioactive material normally inside the body. In addition, people are exposed to radiation through medical procedures such as x-rays, nuclear medicine exams such as positron emission tomography (PET) scans, and by consumer products such as granite countertops and some ceramics.

Table 3. Summary of Effective Whole-Body Annual Radiation Dose to Residents

Annual whole-body effective committed dose range, millirem per year*	ATSDR minimal risk level, millirem per year above background[2]	Natural background, millirem per year[2]
9 to 23	100	360

* Doses are for annual inhalation exposure. The whole-body effective committed dose to age 70 is applied in the year of intake.
Annual whole-body effective committed dose range corresponds to the highest annual dose for any age group.
Doses are estimated using exposure point concentrations without subtracting background.
Ingestion dose from public water not evaluated. Water quality reports are below EPA limits.

The estimated effective whole-body doses for residential exposures at White Mesa are lower than ATSDR's chronic MRL. Younger age groups had higher estimated effective whole-body doses than adults; however, all doses were below the MRL.

The chronic MRL is based on studies showing that natural and artificial sources of ionizing radiation ("background") give a person in the U.S., on average, an effective whole-body dose of 360 mrem per year. No harmful effects have been shown to be associated with this dose [3,11]. Several locations around the world have much higher levels of natural background radiation than the United States. People living in these areas with higher background radiation do not have increased rates of cancer or noncancer health effects compared to other locations.

Summary of Findings

As detailed above, ATSDR's evaluation found

Residential air exposures do not result in elevated risks of adverse cancer or noncancer health effects from radiological material.

Residential drinking water quality reports are within the U.S. EPA regulatory limits. For radiological water quality standards, these limits have been shown to be protective of human health and are below the ATSDR minimal risk level and were not evaluated further.

Residents of the White Mesa community are unlikely to experience adverse health effects from radiological contaminants in air or public supplied drinking water in White Mesa.

[2] The MRL is based on the average annual effective dose equivalent from the early 1980s, 360 mrem per year. In 2006, this value was revised upwards to 620 mrem per year based largely on increased doses from from medical diagnostic procedures [11]. The MRL remains protective because it is a fraction of the annual average U.S. effective dose.

Conclusions

Based on the evaluation and specific assumptions detailed in this report, we reached the following conclusions.

Children and adults who drink the water from the Ute Mountain Ute Tribe public water system are unlikely to be harmed from radiological contaminants.

Drinking water sampling data provided by the Ute Mountain Ute Tribe are below the U.S. Environmental Protection Agency's (EPA's) maximum contaminant level for all radiological contaminants. This means radiological doses are less than ATSDR's minimal risk level.

Children and adults living in White Mesa are unlikely to be harmed from breathing radiological contaminants in the air. ATSDR cannot evaluate other areas of concern.

To evaluate possible effects from air exposures, ATSDR estimated the radiation exposure and resulting dose for residents of various age groups who breathed unfiltered air. We assumed they were always exposed to the highest reported concentrations of contaminants. Estimated annual radiological doses calculated from Ute Mountain Ute Tribe air sampling data taken within the White Mesa Community are below ATSDRs minimal risk level for radiation, which means that observable adverse health effects are unlikely. ATSDR does not have air sampling data to evaluate other areas of concern.

ATSDR cannot evaluate if radon emissions from the mill could impact bordering properties or residents.

ATSDR does not have radon sampling data for the locations of interest to the Ute Mountain Ute Tribe.

ATSDR cannot evaluate if soil and vegetation present a radiation hazard.

ATSDR does not have radiological soil and vegetation sampling data to evaluate.

ATSDR cannot evaluate if seeps and springs present a radiation hazard.

ATSDR does not have radiological seeps and springs sampling data to evaluate.

Recommendations

ATSDR recommends that:

- The Ute Mountain Ute Tribe continue to monitor public water drinking supplies in accordance with all applicable U.S. EPA regulations.

- The Ute Mountain Ute Tribe collect air samples in areas of concern closer to the uranium mill property boundary and during periods of elevated mill activity. These data can be used to characterize radiological material at the sample location. ATSDR also recommends that the Ute Mountain Ute Tribe consult with either ATSDR or U.S. EPA to determine the need and locations of air sampling that would be indicative of background air concentrations.

- The Ute Mountain Ute Tribe collect radon samples in areas of interest to the Ute Mountain Ute Tribe.

- The Ute Mountain Ute Tribe collect soil samples in locations of interest

- The Ute Mountain Ute Tribe collect water samples from seeps and springs.

Next Steps

ATSDR will:

- Review new environmental data, upon request, as it becomes available. If that review requires modifications to these conclusions and recommendations, ATSDR will issue an updated public health consultation.

- Remain available to assist the Ute Mountain Ute Tribe in designing a sampling strategy and choosing sampling locations for the next round of air sampling.

- Address non-radiological chemical and metal hazards in a future health consultation.

- Remain available to provide further technical assistance to the public, partner agencies, or other stakeholders.

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References

[1] Archuleta J. 2019. Petition Letter from Ute Mountain Ute Tribe to ATSDR. February 4, 2019.

[2] Naftz, D.L., Ranalli, A.J., Rowland, R.C., and Marston, T.M., 2011, Assessment of potential migration of radionuclides and trace elements from the White Mesa Uranium Mill to the Ute Mountain Ute Reservation and surrounding areas, Southeastern Utah: U.S. Geological Survey Science Investigations Report 2011–5231, 146 p.

[3] Agency for Toxic Substances and Disease Registry. Toxicological Profile for Ionizing Radiation. Atlanta (GA):US Department of Health and Human Services; 1999.

[4] Agency for Toxic Substances and Disease Registry. Public Health Assessment Guidance Manual (PHAGM). Atlanta (GA): U.S. Department of Health and Human Services; available at: https://www.atsdr.cdc.gov/pha-guidance/

[5] Archuleta J. E-mail to A. Trubiano of the Agency for Toxic Substances and Disease Registry Subject: Drinking Water Testing at White Mesa Utah, containing attachments entitled "White Mesa Consumer Confidence Drinking Water Report 2015 084990004.pdf", "wm cc 2016.pdf", "wm ccr 18 revised PWWS 4990004.pdf", "wm ccr 2017.pdf" White Mesa: Ute Mountain Ute Tribe Environmental Programs Department, received Tuesday, November 06, 2019 6:01 pm.

[6] Archuleta J. E-mail to A. Trubiano of the Agency for Toxic Substances and Disease Registry Subject: FW: White Mesa Data, containing attachments entitled "image001.png", "1308189.xlsx", "UMUT RAD Air filter number location and hours sampled.xlsx" White Mesa: Ute Mountain Ute Tribe Environmental Programs Department, received Tuesday, November 06, 2019 6:20 pm.

[7a] YBG. (2020). *Decay Chain of Actinium.svg*. File: Decay Chain of Actinium.svg. Wikimedia Commons, the free media repository. Retrieved September 22, 2021, from https://commons.wikimedia.org/w/index.php?title=File:Decay_Chain_of_Actinium.svg&oldid=504977826. https://creativecommons.org/licenses/by-sa/3.0/deed.en. No changes were made.

[7b] Sacamol. (2020). *Decay Chain Thorium.svg*. File: Decay Chain Thorium.svg. Wikimedia Commons, the free media repository. Retrieved September 22, 2021, from https://commons.wikimedia.org/w/index.php?title=File:Decay_Chain_Thorium.svg&oldid=492085432. https://creativecommons.org/licenses/by-sa/3.0/deed.en. No changes were made.

[7c] RicHard-59. (2021). *Decay chain (4n+2, Uranium series).svg*. File: Decay chain (4n+2, Uranium series).svg. Wikimedia Commons, the free media repository. Retrieved September 22, 2021, from https://commons.wikimedia.org/w/index.php?title=File:Decay_chain(4n%2B2,_Uranium_series).svg&oldid=526951987. https://creativecommons.org/licenses/by/3.0/deed.en No changes were made.

[8] Archuleta J. E-mail to A. Trubiano of the Agency for Toxic Substances and Disease Registry Subject: FW: White Mesa, containing attachments entitled "map data for white mesa station.JPG", "UMUT map with AQ Stations.tif" White Mesa: Ute Mountain Ute Tribe Environmental Programs Department, received Tuesday, February 04, 2020 3:58 pm.

[9] International Commission on Radiological Protection. Compendium of dose coefficients based on ICRP Publication 60. ICRP Publication 119. Ann ICRP 41(Suppl). 2012.

[10] Howlader N, Noone AM, Krapcho M, Miller D, Bishop K, Kosary CL, Yu M, Ruhl J, Tatalovich Z, Mariotto A, Lewis DR, Chen HS, Feuer EJ, Cronin KA (eds). SEER Cancer Statistics Review, 1975-2014, National Cancer Institute. Bethesda (MD): April 2017. Available at: https://seer.cancer.gov/csr/1975_2014/. Accessed on 10/01/2021.

[11] National Council on Radiation Protection and Measurements. Ionizing radiation exposure of the population of the United States. NCRP Report No. 160. Bethesda (MD): National Council on Radiation Protection and Measurements, March 3, 2009.

[12] Archuleta J. E-mail to K. Elgethun of the Agency for Toxic Substances and Disease Registry Subject: White Mesa Residents Activity, containing attachment entitled "White Mesa residents Mini-survey.docx" White Mesa: Ute Mountain Ute Tribe Environmental Programs Department, received Tuesday, October 13, 2020 10:07 am.

[13] U.S. Environmental Protection Agency. Exposure factors handbook, 2011 edition. EPA/600/R-09/052F. Washington (DC): U.S. Environmental Protection Agency; 2011.

[14] Radiological Toolbox Version 3.0.0 available from the U.S. Nuclear Regulatory Commission Radiation Protection Computer Code Analysis and Maintenance Program. Available at https://ramp.nrc-gateway.gov/.

[15] U.S. Environmental Protection Agency. (2002). *Radionuclides in drinking water: A small entity compliance guide*.

Appendix A. Community Exposure Input and ATSDR Selected Parameters

To estimate exposures, we use information on how often and for how long the activities associated with the exposure occurred. We obtained input on White Mesa resident activity and frequency from the Ute Mountain Ute Tribe. The following explains how we used this information in selecting exposure assumptions. Tables summarizing the selected parameters are included in this appendix. Also included are ATSDR's selected intake parameters for inhalation used in this health consultation.

Community Input on Exposure Assumptions

The Ute Mountain Ute Tribe provided input on how often adult and children residents of various ages in White Mesa participated in certain activities. Age ranged from three through adults. Time spent outdoors during various times of the year such as during school days, non-school days, yardwork, and other recreational activities were provided. The greatest estimate of time outdoors was 6 hours per day. The Ute Mountain Ute Tribe table of exposure frequencies can be seen in Figure 7 [12].

Figure 7. Ute Mountain Ute Tribe Furnished Exposure Frequencies [12]

White Mesa Mini-survey of activities or time spent outside

Survey performed by Janice Archuleta on Oct. 7, 2020

Category	Age	Time Outside	Activity
Preschool – 1 class (2020) 2 classes previous years	3-4	20 min.	Preschool activities – bikes, balls
White Mesa Resident 1	In 30's	Bad allergies--does not go outside	
White Mesa Resident 1 Has 2 children	1 pre-teen 1 teen	3 hrs/day	Assist grandfather with wood gathering Use/shoot pellet guns
White Mesa Resident 2	In 40's		
White Mesa Resident 2 Has 2 children	1 pre-teen 1 teen	5 hrs/day no school 2 hrs/day in school	
White Mesa Resident 3	In 30's	Is outside with children – see below	
White Mesa Resident 3 Has 2 children	1 pre-teen 1 teen	6 hrs/day no school 3 hrs/day in school	Pre-teen spends less time outside when cold and bad weather
White Mesa Resident 4	In 20's	40 min at work – 1 hour every other day - hiking	Strenuous activities at Gas Station Hiking
White Mesa Employee -does not live there	In 40's	Takes 10-15 minute breaks and walks around outside	
White Mesa Resident 4		2-3 hours	Doing yardwork and going in and out of house
White Mesa Resident 4 Has 4 children	2 grade school 1 pre-teen 1 teen	2-3 hours	Trampoline Teenager has football practice in Blanding for 2 hours otherwise about 1 hour outside

- One resident said no one jogs around the town.
- Another resident from a previous year say they had gone hiking around the mesa each evening.
- Some residents go hunting during hunting season.
- I have witnessed a 4-wheeler for at least 2 hours doing loops around a small area.
- I have seen other residents doing gardening and the maintenance workers are outside doing those activities also.
- Bushwacker Summer Program for kids – 30 minutes or 1 mile walking/running.
- The Tribe traditionally does beadwork and uses juniper beads—so they collect them.

ATSDR Exposure Parameters for Residents

ATSDR selected more conservative exposure frequencies than provided by the Ute Mountain Ute Tribe. We selected an exposure frequency and duration that exceeds the Ute Mountain Ute tribe estimates; 8 hours per day, 365 days per year. This exceeds the Ute Mountain Ute Tribe highest estimated exposure duration of 6 hours per day on non-school days to unfiltered air. ATSDR applied the conservative exposure assumption for all age groups. Table 4 below summarize the exposure assumptions used in this consultation.

Table 4. ATSDR Residential Exposure Assumptions

Age group	Exposure Duration Hours per Day	Exposure Frequency Days Per Year
Newborn	8	365
1-Year-Old	8	365
5-Year-Old	8	365
10-Year-Old	8	365
15-Year-Old	8	365
Adult	8	365

Inhalation Parameters for Residents

ATSDR used the Exposure Factor Handbook by the U.S. EPA, Table 6-2 to select inhalation rates (Figure 8) for this health consultation. Short-term exposure for inhalation under moderate intensity at the 95^{th} percentile provides a conservative estimate under various actives residents might perform. Table 5 below summarize the intake assumptions used in this consultation.

Figure 8. Recommended Short-Term Exposure Values for Inhalation [13]

Table 6-2. Recommended Short-Term Exposure Values for Inhalation (males and females combined) (continued)

Activity Level	Age Group (year)	Mean (m^3/minute)	95th Percentile (m^3/minute)	Multiple Percentiles
Light Intensity (continued)	21 to <31	1.2E−02	1.6E−02	
	31 to <41	1.2E−02	1.6E−02	
	41 to <51	1.3E−02	1.6E−02	
	51 to <61	1.3E−02	1.7E−02	
	61 to <71	1.2E−02	1.6E−02	
	71 to <81	1.2E−02	1.5E−02	
	≥81	1.2E−02	1.5E−02	
Moderate Intensity	Birth to <1	1.4E−02	2.2E−02	
	1 to <2	2.1E−02	2.9E−02	
	2 to <3	2.1E−02	2.9E−02	
	3 to <6	2.1E−02	2.7E−02	
	6 to <11	2.2E−02	2.9E−02	
	11 to <16	2.5E−02	3.4E−02	
	16 to <21	2.6E−02	3.7E−02	
	21 to <31	2.6E−02	3.8E−02	
	31 to <41	2.7E−02	3.7E−02	
	41 to <51	2.8E−02	3.9E−02	
	51 to <61	2.9E−02	4.0E−02	
	61 to <71	2.6E−02	3.4E−02	
	71 to <81	2.5E−02	3.2E−02	
	≥81	2.5E−02	3.1E−02	
High Intensity	Birth to <1	2.6E−02	4.1E−02	
	1 to <2	3.8E−02	5.2E−02	
	2 to <3	3.9E−02	5.3E−02	
	3 to <6	3.7E−02	4.8E−02	
	6 to <11	4.2E−02	5.9E−02	
	11 to <16	4.9E−02	7.0E−02	
	16 to <21	4.9E−02	7.3E−02	
	21 to <31	5.0E−02	7.6E−02	
	31 to <41	4.9E−02	7.2E−02	
	41 to <51	5.2E−02	7.6E−02	
	51 to <61	5.3E−02	7.8E−02	
	61 to <71	4.7E−02	6.6E−02	
	71 to <81	4.7E−02	6.5E−02	
	≥81	4.8E−02	6.8E−02	

Source: U.S. EPA (2009a).

Table 5. ATSDR Selected Inhalation Rates

Age group*	95th Percentile m^3/min**	95th Percentile m^3/hr†
Newborn	2.20E-02	1.32E+00
1-Year-Old	2.90E-02	1.74E+00
5-Year-Old	2.90E-02	1.74E+00
10-Year-Old	3.40E-02	2.04E+00
15-Year-Old	3.70E-02	2.22E+00
Adult	4.00E-02	2.40E+00

* Selected age groups from Radiological Toolbox [14]

** m^3/min = cubic meters per minute

** Short-term moderate intensity 95th Percentile from Exposure Factors Handbook [13]

** Highest value selected corresponding to age group

† m^3/hr = cubic meters per hour (converted from m^3/min)

Appendix B. Pathway Analysis and Selecting Contaminants to Evaluate Further

Pathway Analysis

ATSDR evaluates whether people may have come into contact with contaminants from a site by examining *exposure pathways*. 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 [4].

Completed exposure pathways are those for which all five pathway elements are evident. If one or more elements is missing or has been stopped, 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.

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

Below, we discuss the five exposure pathway elements as they describe potential exposure pathways relevant to residents of White Mesa.

- The *source* of potential contamination is storage piles and settling ponds of mill tailing waste
- Offsite *transport* of the contaminants via wind and groundwater seepage is possible
- *Exposure point* is the vicinity of air sampling location and public water supplies
- *Exposure route* is inhalation of contaminants and ingestion of public water
- *Exposed population* includes White Mesa residents of varying ages

Selecting Contaminants to be Evaluated Further

Radiological Screening

Air and water quality reports were available for review. Water quality reports for radiological contaminants were below the EPA maximum contaminant level and were not further evaluated; summarized in Table 6 below. Air sampling results were available for several contaminants provided by the Ute Mountain Ute Tribe. The laboratory reported 53 different samples resulting in nearly two thousand results. Laboratory results were subjected to internal quality control processes. Samples not meeting the data standards are noted with the presence of a qualifier or flag. Sample results flagged with identifiers such as a U (result is less than the sample specific minimum detectable concentration), Y2 (chemical yield outside default limits), or those identified as spiked samples were not used by ATSDR in this evaluation. Isotopes that are short lived and those not associated with actinium, uranium, and thorium decay chains were also dropped. Table 7 summarizes the radiological data for unfiltered air. ATSDR included isotopes in the actinium, uranium, and thorium decay series in this evaluation. These natural decay series are ubiquitous, but as a result of the milling, concentrations of decay products can become elevated over background levels.

Table 6. Water Quality Report Screening

Contaminant	EPA Maximum Contaminant Level pCi/L** [9]	Highest Reported Result [5]
Beta/photon emitters	50 pCi/L	5.5 pCi/L
Gross alpha	15 pCi/L	3.4 pCi/L
Combined radium -226,228	5 pCi/L	<0.5 pCi/L
Uranium	20.1 pCi/L*	0.06 pCi/L

* Converted from EPA maximum contaminant level of 30 micrograms per liter

** pCi/L = picocuries per litre

Table 7. Summary of Screened Air Contaminants

Radiological Contaminants Retained for Evaluation (positive samples/number of samples)		
Thorium-228 (4/33)	Lead-210 (25/36)	Uranium-234 (27/39)
Thorium-230 (7/39)	Polonium-210 (28/39)	Uranium-235 (6/69)
Thorium-232 (15/33)	Radium-226 5/39	Uranium-238 (23/39)
Contaminants Dropped from Evaluation (positive samples/number of samples)		
Gross Alpha (29/39)	Americium-241 (0/39)	Manganese-54 (0/36)
Gross Beta (30/39)	Cerium-139 (0/36)	Sodium-22 (0/36)
Non-radioactive Lead (1/2)	Cerium-144 (0/36)	Niobium-94 (0/36)
Non-radioactive Barium (0/1)	Cobalt-56 (0/36)	Niobium-95 (0/36)
Actinium-228 (10/36)	Cobalt-57 (0/36)	Protactinium-234m (0/36)
Aluminum-26 (1/36)	Cobalt-58 (0/36)	Polonium-209 (0/39)
Beryllium-7 (26/36)	Cobalt-60 (0/39)	Ruthenium-106 (0/36)
Bismuth-212 (1/36)	Chromium-51 (0/36)	Antimony-125 (0/36)
Bismuth-214 (6/36)	Cesium-134 (0/36)	Scandium-46 (0/36)
Iron-59 (1/36)	Cesium-137 (0/39)	Thorium-227 (0/36)
Lead-212 (2/36)	Europium-152 (0/36)	Thorium-229 (0/39)
Lead-214 (6/36)	Europium-154 (0/36)	Thorium-234 (1/36)
Antimony-124 (5/36)	Europium-155 (0/36)	Uranium-232 (0/39)
Thallium-208 (5/36)	Iodine-131 (0/36)	Zinc-65 (0/36)
Silver-110m (0/36)	Potassium-40 (0/36)	
Note: Samples flagged as not meeting lab standards, short lived isotopes, and those not associated with actinium, uranium, and thorium decay chains were dropped from this evaluation.		

Appendix C. Contaminant Intake and Intake Calculation

To estimate how much of each contaminant is taken in by residents who might inadvertently inhale contamination, ATSDR estimated conservative exposure point concentrations (EPC) for the contaminants of concern. Combining the exposure assumptions and inhalation rates in appendix A, with the retained contaminant exposure point concentrations in Table 2, ATSDR calculated annual contaminant intakes using Equation 1 below. Annual inhalation intakes are presented in Tables 8-13 below.

Equation 1. Unfiltered Air Inhalation Intake

$$\text{Intake}\left(\frac{\text{pCi}}{\text{year}}\right) = \text{EPC}\left(\frac{\text{pCi}}{\text{m}^3}\right) \times \text{inhalation rate}\left(\frac{\text{m}^3}{\text{hr}}\right) \times \text{hrs per day}\left(\frac{\text{hr}}{\text{day}}\right) \times \text{Days per year}\left(\frac{\text{days}}{\text{year}}\right)$$

Table 8. Annual Intake for Age Group: Newborn

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	2.62E+02	6.80E-02	1.32E+00	8	365
Polonium-210	2.93E+02	7.60E-02	1.32E+00	8	365
Radium-226	4.47E+00	1.16E-03	1.32E+00	8	365
Thorium-228	8.87E-01	2.30E-04	1.32E+00	8	365
Thorium-230	8.87E-01	2.30E-04	1.32E+00	8	365
Thorium-232	6.13E-01	1.59E-04	1.32E+00	8	365
Uranium-234	5.16E+00	1.34E-03	1.32E+00	8	365
Uranium-235	6.17E-01	1.60E-04	1.32E+00	8	365
Uranium-238	4.63E+00	1.20E-03	1.32E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Table 9. Annual Intake for Age Group: 1-Year-Old

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	3.45E+02	6.80E-02	1.74E+00	8	365
Polonium-210	3.86E+02	7.60E-02	1.74E+00	8	365
Radium-226	5.89E+00	1.16E-03	1.74E+00	8	365
Thorium-228	1.17E+00	2.30E-04	1.74E+00	8	365
Thorium-230	1.17E+00	2.30E-04	1.74E+00	8	365
Thorium-232	8.08E-01	1.59E-04	1.74E+00	8	365
Uranium-234	6.81E+00	1.34E-03	1.74E+00	8	365
Uranium-235	8.13E-01	1.60E-04	1.74E+00	8	365
Uranium-238	6.10E+00	1.20E-03	1.74E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Table 10. Annual Intake for Age Group: 5-Year-Old

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	3.45E+02	6.80E-02	1.74E+00	8	365
Polonium-210	3.86E+02	7.60E-02	1.74E+00	8	365
Radium-226	5.89E+00	1.16E-03	1.74E+00	8	365
Thorium-228	1.17E+00	2.30E-04	1.74E+00	8	365
Thorium-230	1.17E+00	2.30E-04	1.74E+00	8	365
Thorium-232	8.08E-01	1.59E-04	1.74E+00	8	365
Uranium-234	6.81E+00	1.34E-03	1.74E+00	8	365
Uranium-235	8.13E-01	1.60E-04	1.74E+00	8	365
Uranium-238	6.10E+00	1.20E-03	1.74E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Table 11. Annual Intake for Age Group: 10-Year-Old

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	4.05E+02	6.80E-02	2.04E+00	8	365
Polonium-210	4.53E+02	7.60E-02	2.04E+00	8	365
Radium-226	6.91E+00	1.16E-03	2.04E+00	8	365
Thorium-228	1.37E+00	2.30E-04	2.04E+00	8	365
Thorium-230	1.37E+00	2.30E-04	2.04E+00	8	365
Thorium-232	9.47E-01	1.59E-04	2.04E+00	8	365
Uranium-234	7.98E+00	1.34E-03	2.04E+00	8	365
Uranium-235	9.53E-01	1.60E-04	2.04E+00	8	365
Uranium-238	7.15E+00	1.20E-03	2.04E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Table 12. Annual Intake for Age Group: 15-Year-Old

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	4.41E+02	6.80E-02	2.22E+00	8	365
Polonium-210	4.93E+02	7.60E-02	2.22E+00	8	365
Radium-226	7.52E+00	1.16E-03	2.22E+00	8	365
Thorium-228	1.49E+00	2.30E-04	2.22E+00	8	365
Thorium-230	1.49E+00	2.30E-04	2.22E+00	8	365
Thorium-232	1.03E+00	1.59E-04	2.22E+00	8	365
Uranium-234	8.69E+00	1.34E-03	2.22E+00	8	365
Uranium-235	1.04E+00	1.60E-04	2.22E+00	8	365
Uranium-238	7.78E+00	1.20E-03	2.22E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Table 13. Annual Intake for Age Group: Adult

Contaminant	Intake (pCi/year)**	EPC* (pCi/m^3)**†	Inhalation rate (m^3/hour) †	Hours per Day (hours/day)	Days per Year (days/year)
Lead-210	4.77E+02	6.80E-02	2.40E+00	8	365
Polonium-210	5.33E+02	7.60E-02	2.40E+00	8	365
Radium-226	8.13E+00	1.16E-03	2.40E+00	8	365
Thorium-228	1.61E+00	2.30E-04	2.40E+00	8	365
Thorium-230	1.61E+00	2.30E-04	2.40E+00	8	365
Thorium-232	1.11E+00	1.59E-04	2.40E+00	8	365
Uranium-234	9.39E+00	1.34E-03	2.40E+00	8	365
Uranium-235	1.12E+00	1.60E-04	2.40E+00	8	365
Uranium-238	8.41E+00	1.20E-03	2.40E+00	8	365

* EPC= Exposure point concentration
* The maximum EPC was used for all calculations
** pCi = Picocuries
† m^3 = cubic meters

Appendix D. Radiological Dose

Radiological Dose

Intake itself does not completely determine the radiological dose. Determining the radiological dose resulting from intake is a complicated function of the identity of the radiological isotope, how it enters the body (ingestion or inhalation), how much is taken in, how much is eliminated or metabolized, what organs it is stored in, and how it changes as it radioactively decays. Each radioactive isotope has different characteristics. The International Commission on Radiological Protection (ICRP) has derived dose coefficients for estimating radiological dose from a given intake at different times after exposure for different isotopes and different age groups.[9]

For this evaluation, ATSDR used dose coefficients for the general public obtained from the program "Radiological Toolbox" v. 3.0.0 (available as a download from the Nuclear Regulatory Commission). This program provides internal dose coefficients based on ICRP Publication 68/72. [14,9] More details about the dose coefficients selected and example calculations for internal dose are provided below.

Calculation of Internal Dose

Radioactive material taken up by the body continues to deliver a radiation dose over a person's lifetime. We determined the committed radiological dose to age 70 for one year of intake for each age group. The committed dose to age 70 is defined as the dose that will accumulate in a person's body from the time of intake to age 70; this entire dose is considered to occur in the year of the intake. In this report, we will refer to the committed dose to age 70 as "committed dose."

The annual committed dose to age 70 to the whole body, resulting from a specific radiological intake, is given by Equation 2 below.

Equation 2. Whole-body Committed Dose

$$AnnualDose_i\left(\frac{millirem}{year}\right) = \sum_{contaminants} intake\left(\frac{pCi}{year}\right) \times DCF_{70-yr,i}\left(\frac{millirem}{pCi}\right)$$

Where the annual whole-body dose *i* is the annual intake of each isotope multiplied by the committed dose coefficient corresponding to the specific isotope and age group during the year of intake; these intake-dose coefficient products are then summed for all isotopes considered.

Inhalation dose coefficients vary depending on how quickly the contaminant dissolves in lung fluid. We used the default recommended solubility dose coefficients for this health consultation. Also, internal dose coefficients for inhalation include the contribution of dose from radioactive decay products formed from the material inhaled for as long as the material is in the body. Annual whole-body committed doses are presented in Tables 14 – 19 below.

Table 14. Annual Whole-Body Committed Dose for Age Group: Newborn

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	4.85E+00	2.62E+02	1.85E-02
Polonium-210	1.63E+01	2.93E+02	5.56E-02
Radium-226	2.48E-01	4.47E+00	5.56E-02
Thorium-228	5.25E-01	8.87E-01	5.93E-01
Thorium-230	1.31E-01	8.87E-01	1.48E-01
Thorium-232	1.23E-01	6.13E-01	2.00E-01
Uranium-234	2.87E-01	5.16E+00	5.56E-02
Uranium-235	2.97E-02	6.17E-01	4.81E-02
Uranium-238	2.06E-01	4.63E+00	4.44E-02
∑ Annual Committed Dose (mrem/year) = 2.27E+01 mrem/year or approximately 23 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Table 15. Annual Whole-Body Committed Dose for Age Group: 1-Year-Old

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	4.73E+00	3.45E+02	1.37E-02
Polonium-210	1.57E+01	3.86E+02	4.07E-02
Radium-226	2.40E-01	5.89E+00	4.07E-02
Thorium-228	5.63E-01	1.17E+00	4.81E-01
Thorium-230	1.51E-01	1.17E+00	1.30E-01
Thorium-232	1.50E-01	8.08E-01	1.85E-01
Uranium-234	2.77E-01	6.81E+00	4.07E-02
Uranium-235	3.01E-02	8.13E-01	3.70E-02
Uranium-238	2.12E-01	6.10E+00	3.48E-02
∑ Annual Committed Dose (mrem/year) = 2.21E+01 mrem/year or approximately 22 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Table 16. Annual Whole-Body Committed Dose for Age Group: 5-Year-Old

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	2.82E+00	3.45E+02	8.15E-03
Polonium-210	9.58E+00	3.86E+02	2.48E-02
Radium-226	1.53E-01	5.89E+00	2.59E-02
Thorium-228	3.55E-01	1.17E+00	3.04E-01
Thorium-230	1.04E-01	1.17E+00	8.89E-02
Thorium-232	1.11E-01	8.08E-01	1.37E-01
Uranium-234	1.77E-01	6.81E+00	2.59E-02
Uranium-235	1.90E-02	8.13E-01	2.33E-02
Uranium-238	1.33E-01	6.10E+00	2.19E-02
∑ Annual Committed Dose (mrem/year) = 1.34E+01 mrem/year or approximately 14 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Table 17. Annual Whole-Body Committed Dose for Age Group: 10-Year-Old

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	2.25E+00	4.05E+02	5.56E-03
Polonium-210	7.71E+00	4.53E+02	1.70E-02
Radium-226	1.25E-01	6.91E+00	1.81E-02
Thorium-228	2.79E-01	1.37E+00	2.04E-01
Thorium-230	8.12E-02	1.37E+00	5.93E-02
Thorium-232	9.12E-02	9.47E-01	9.63E-02
Uranium-234	1.42E-01	7.98E+00	1.78E-02
Uranium-235	1.52E-02	9.53E-01	1.59E-02
Uranium-238	1.06E-01	7.15E+00	1.48E-02
∑ Annual Committed Dose (mrem/year) = 1.08E+01 mrem/year or approximately 11 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Table 18. Annual Whole-Body Committed Dose for Age Group: 15-Year-Old

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	2.12E+00	4.41E+02	4.81E-03
Polonium-210	7.30E+00	4.93E+02	1.48E-02
Radium-226	1.25E-01	7.52E+00	1.67E-02
Thorium-228	2.60E-01	1.49E+00	1.74E-01
Thorium-230	8.28E-02	1.49E+00	5.56E-02
Thorium-232	9.54E-02	1.03E+00	9.26E-02
Uranium-234	1.35E-01	8.69E+00	1.56E-02
Uranium-235	1.42E-02	1.04E+00	1.37E-02
Uranium-238	9.80E-02	7.78E+00	1.26E-02
∑ Annual Committed Dose (mrem/year) = 1.02E+01 mrem/year or approximately 10 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Table 19. Annual Whole-Body Committed Dose for Age Group: Adult

Contaminant	Annual Committed Dose (mrem/year) *	Intake (pCi/year)**	Dose Coefficient (mrem/pCi)†
Lead-210	1.94E+00	4.77E+02	4.07E-03
Polonium-210	6.51E+00	5.33E+02	1.22E-02
Radium-226	1.05E-01	8.13E+00	1.30E-02
Thorium-228	2.39E-01	1.61E+00	1.48E-01
Thorium-230	8.36E-02	1.61E+00	5.19E-02
Thorium-232	1.03E-01	1.11E+00	9.26E-02
Uranium-234	1.22E-01	9.39E+00	1.30E-02
Uranium-235	1.29E-02	1.12E+00	1.15E-02
Uranium-238	9.03E-02	8.41E+00	1.07E-02
∑ Annual Committed Dose (mrem/year) = 9.21E+00 mrem/year or approximately 9 mrem/year			

* mrem/year =millirem per year

** pCi/year= picocurie per year

† mrem/pCi = millirem per picocurie

Appendix E. ATSDR Response to Community Health Concerns

The Ute Mountain Ute Tribe White Mesa Community is concerned about potential current and past contamination of the environment in and surrounding the White Mesa Community (Community) related to the White Mesa Uranium Mill (Mill). The Ute Mountain Ute Tribe petitioned ATSDR about multi-pathway exposure concerns and related health hazards. The following concerns were shared by the Ute Mountain Ute Tribe and are specific to the air exposure pathway. The Ute Mountain Ute Tribe also has concerns about water, soil, and biota pathways that will be addressed in the second ATSDR document that responds to the petition.

Community Concern: After 40 years of the White Mesa Mill operating, are resuspension and deposition of the dry and wet thorium and uranium from the Mill contributing to more risk to the community members? Has uranium and thorium-associated particulate air pollution from the Mill caused a health hazard to the Community in the past? Is uranium and thorium-associated particulate air pollution from the Mill causing a health hazard to the community now?

ATSDR Response: Based on the data analyzed in this report, estimated annual radiological doses are below ATSDR's minimal risk level (MRL) and are unlikely to harm health. This conclusion is based on data that are specific to location and specific to the timeframe in which they were collected. It is possible that there are locations closer to the Mill where air concentrations of radioactive material may be higher than the sampled location. It is also possible that past time periods may have had higher or lower radiological air concentrations, however we do not have data for all time periods. To answer the question about risk at locations closer to the Mill, ATSDR recommends sampling on tribal and tribal-use lands closer to the Mill. ATSDR is available to analyze any new data.

Community Concern: Has uranium and thorium-associated particulate air pollution from the Mill caused a health hazard to people using Tribal lands adjacent to the Mill in the past? Is uranium and thorium-related particulate air pollution from the Mill causing a health hazard to people using Tribal lands adjacent to the Mill now?

ATSDR Response: As stated above, we cannot predict exposures in the past with the data available. The estimated annual radiological doses calculated in this report represent the vicinity of the air sampling location. These annual radiological doses are below ATSDR's minimal risk level (MRL) and are unlikely to harm health. To answer the question of exposure risk on tribal and tribal-use lands in locations closer to the mill, ATSDR needs sampling data from locations of interest closer to the Mill. ATSDR is available to analyze any new data.

Community Concern: Is there evidence that radon from the Mill causes radon levels to rise onsite, and to rise at the background sampling location when the Mill is running? Is there evidence that radon levels are affected by the reprocessing of waste pond water at the Mill, which causes pond levels to drop in violation of NESHAPs Subpart W? Does radon from the Mill pose a current or past health hazard to the Community or to people using tribal or tribal-use lands?

ATSDR Response: ATSDR is a nonregulatory health-based agency and does not review or evaluate radiological data from sites that operate under a license from the Nuclear Regulatory Commission or, by extension, Agreement States. Radon is a gas and will quickly dissipate in open environments. Radon in enclosed environments such as houses can accumulate and pose an increased health risk. ATSDR suggests residents and homeowners concerned about radon have their dwellings tested and take mitigating actions if needed. For information on radon testing contact the Utah Department of Environmental Quality, Waste Management & Radiation Control at https://deq.utah.gov/division-waste-management-radiation-control or by telephone at (801) 536-0200. ATSDR is available to analyze any new data.

Community Concern: Are background air radon samples measured at a former Pershing Missile Launch Site (Black Mesa, UT) acceptable for determining natural background radioactivity given the history of the site and potential radioactive materials used there? Is it normal for background radon samples to be higher than those samples measured adjacent to the Mill which is a known source? Should another background site be considered given possible Pershing Missile-related radioactive contamination of the background site and possible influence of the Mill on radon levels at the background site?

ATSDR Response: ATSDR is a nonregulatory health-based agency and does not review or evaluate radiological data from sites that operate under a license from the Nuclear Regulatory Commission or by extension, Agreement States. Radon is a gas and will move through the ground and emerge in unpredictable ways. It is not uncommon to have large variations in radon concentrations over short distances. Since the variations in radon can be large, differentiating between naturally occurring radon and radon from any offsite radiological material is not possible. As stated previously, radon in enclosed environments such as houses can accumulate and pose an increased health risk. ATSDR suggests residents and homeowners concerned about radon have their dwellings tested and take mitigating actions if needed. For information on radon testing contact the Utah Department of Environmental Quality, Waste Management & Radiation Control at https://deq.utah.gov/division-waste-management-radiation-control or by telephone at (801) 536-0200. ATSDR is available to analyze any new data.

Community Concern: Could the high rates of adverse health effects experienced by the community members be due the proximity of the community to the Nevada Test Site?

ATSDR Response: According to the U.S. Justice Department, all of San Juan County, UT is an affected downwind area from the Nevada Test Site. As such it is possible that community members' health could have been affected by fallout from tests at the site. More information is available at https://www.justice.gov/civil/common/reca