Public Health Assessment

Initial/Public Comment Release

Monticello Mill Tailings and Vicinity Properties
Monticello, San Juan County, Utah

EPA FACILITY ID: UT0001119296

Prepared by
The Utah Department of Health

JANUARY 4, 2013

COMMENT PERIOD ENDS: FEBRUARY 4, 2013

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment-Public Comment Release was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR's Cooperative Agreement Partner has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate. This document represents the agency's best efforts, based on currently available information, to fulfill the statutory criteria set out in CERCLA section 104 (i)(6) within a limited time frame. To the extent possible, it presents an assessment of potential risks to human health. Actions authorized by CERCLA section 104 (i)(11), or otherwise authorized by CERCLA, may be undertaken to prevent or mitigate human exposure or risks to human health. In addition, ATSDR's Cooperative Agreement Partner will utilize this document to determine if follow-up health actions are appropriate at this time.

This document has now been released for a 30-day public comment period. Subsequent to the public comment period, ATSDR's Cooperative Agreement Partner will address all public comments and revise or append the document as appropriate. The public health assessment will then be reissued. This will conclude the public health assessment process for this site, unless additional information is obtained by ATSDR's Cooperative Agreement Partner which, in the agency's opinion, indicates a need to revise or append the conclusions previously issued.

Please address comments regarding this report to:

Agency for Toxic Substances and Disease Registry
Attn: Records Center
1600 Clifton Road, N.E., MS F-09
Atlanta, Georgia 30333

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PUBLIC HEALTH ASSESSMENT

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Prepared by:

Environmental Epidemiology Program
Bureau of Epidemiology
The Utah Department of Health
Under A Cooperative Agreement with the
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SUMMARY

Introduction

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal agency based in Atlanta, GA. ATSDR serves the public by applying the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and disease(s) related to toxic substances. ATSDR has entered into a cooperative agreement with Utah's Environmental Epidemiology Program (EEP) to assess how people could become sick if they contacted contaminants anywhere in Utah's environment.

Background

Beginning in 1942, the U.S. government milled uranium and vanadium at a site near Monticello, Utah. The U.S. Atomic Energy Commission (AEC) eventually took over the site. Milling activity stopped in 1960.

The problems related to the site did not stop. Workers at the site and residents in and around Monticello remained concerned about health risks from possible site-related radioactivity. In 1961, site cleanup activities began. By 1980, the AEC set up its Remedial Action Project. In 1983, the AEC split the project into two parts. The site itself became the Monticello Mill Tailings Site (MMTS), and private properties near the site became the Monticello Vicinity Properties Site (MVP).

U.S. EPA added MVP to NPL

On June 10, 1986, the MVP [EPA ID No. UTD980667208] was added to National Priorities List (NPL) of Comprehensive Environmental Response, Compensation, and Liability (CERCLA) Superfund sites. On November 21, 1989, the MMTS [EPA ID No. UT3890090035] was added to the NPL.

Under regulatory management by the U.S. Environmental Protection Agency (EPA) and Utah Department of Environmental Quality (UDEQ), the DOE has conducted remediation at these sites. In 2000, the MVP was deleted from the NPL. The MMTS remains in the NPL.

This Public Health Assessment (PHA) was conducted by the EEP in response to resident concerns about radioactive materials and heavy metals in the City of Monticello and surrounding area that came from the MMTS.

MVP removed from NPL

The first PHA regarding the MMTS and the MVP was conducted in 1997. The first CERCLA 5-year review was completed that year. In 2007, the third CERCLA 5-year review was completed. The latest review concluded that remedies instituted by the DOE were protective of human health.

Continued site-related health concerns

Resident concerns continued about remaining radioactivity, particularly offsite. The concerns were mainly about the possible site-related radioactive materials and heavy metals moving by water, air, or the food chain into the City of Monticello and into the surrounding area. In response to such resident concerns, the Utah EEP conducted this Public Health Assessment (PHA).

This PHA's purpose

The purpose of this PHA is to review contaminant sampling data collected since the original PHA. All samples were collected by either Utah Department of Environmental Quality (UDEQ) or the EPA Region 8 representatives. In an attempt to characterize the nature and degree of exposure to MMTS contaminants in the community, the EEP conducted a comprehensive review of all exposure pathways (groundwater, surface water, indoor air and food chain) and, if data warranted, estimated exposure doses to residents.

Utah EEP's conclusion

Following thorough review of the environmental pathway exposure data, the EEP finds that one intermittent groundwater to surface seep at one location could harm people's health through exposure to uranium. The EEP further finds that the remediation efforts and institutional controls in place at the MMTS have effectively addressed all other pathways of contaminant exposure and that these pathways are not expected to harm people's health.

Conclusion 1

A degree of limited exposure to uranium exists for those in contact with the Montezuma Creek surface waters. These waters are not used as a potable drinking water source and access to the canyon water is limited; therefore, only recreational exposures (involving accidental ingestion) are likely to occur. Therefore, exposures to the surface waters of Montezuma Creek do not pose an apparent health hazard.

Conclusion 1 basis	The dose estimates, compared with the Minimal Risk Level (MRL) values for uranium, do not indicate a potential health risk. But to protect the community's health, no one should use the shallow alluvial groundwater or Montezuma Creek for drinking, cooking, washing clothes, or other home purpose.
Conclusion 1 next steps	Continued monitoring of the canyon water is necessary until remediation activities have reduced contaminant levels to the remediation goals set by the U.S. Department of Energy. The EEP will review additional environmental data as it becomes available.
Conclusion 2	Radon gas exposure is an ongoing concern in Monticello and throughout Utah. Though radon exposures directly related to the MMTS have been mitigated through remediation, naturally occurring radon gas exposures may still exist.
Conclusion 2 basis	The U.S. EPA considers Utah one of many states with the potential for elevated indoor radon levels. Although remediation of Monticello properties is complete, some Monticello properties might still have radon levels above U.S. EPA guidelines. The Utah EEP, DOH, and DEQ all recommend testing Utah homes for radon gas
Conclusion 2 next steps	The EEP will work with the local health department to address residents' concerns regarding radon testing and mitigation.
Conclusion 3	Exposure to contaminants in the shallow alluvial aquifer is possible only through discharge of ground seeps. These seeps are expected to result in only accidental ingestion exposures. Seeps 1-5 do not pose a public health hazard. Data suggests that seep 6 poses a public health hazard for individuals engaged in limited recreational usage. Therefore access to this area should be controlled.
Conclusion 3 basis	The shallow alluvial aquifer is not accessible as a usable (potable of non-potable) water source for the residents of Monticello. Only limited exposure is possible. Exposure dose evaluation of the ground seeps indicates that seep 6 poses health hazard due to potential uranium exposure.

Conclusion 3 next steps	In order to ensure the ongoing protection of community health, the EEP recommends continued monitoring of the shallow alluvial groundwaters below Montezuma Creek. Furthermore, engineering controls should be implemented to mitigate the exposure to seep 6.
Conclusion 4	The Utah EEP looked at the likelihood of arsenic and selenium transfer from grasses into animals people eat as well as into other grazing animals. The EEP also looked at the risk to human health from eating animals and vegetables watered by contaminated groundwater/surface water. The EEP concludes that these pathways are not expected to harm people's health.
Conclusion 4 basis	Although some studies have shown uptake of these contaminants into plants, grasses, and grazing animals, the transfer amounts were found to be low. Such low contaminant amounts should not pose a human health risk to those who eat these plants or who eat meat from these animals.
Conclusion 4 next steps	The Utah EEP recommends continued monitoring of contaminant uptake by plants and animals.
For more information	Call the Utah Department of Health at (801) 538-6191 and ask for additional information about the Monticello Mill Tailings Site.

PURPOSE AND HEALTH ISSUES

The Environmental Epidemiology Program

The Environmental Epidemiology Program (EEP) is a program within the Bureau of Epidemiology in the Utah Department of Health (UDOH). The EEP has a cooperative agreement with the Agency for Toxic Substance and Disease Registry (ATSDR) to conduct site-specific health assessments following ATSDR assessment protocols (ATSDR, 2005b).

The Victims of Mill Tailings Exposure (VMTE) Committee is a group of concerned citizens from the city of Monticello, UT. This group requested that the EEP conduct this PHA to identify possible public health hazards posed by past exposure from the former vanadium and uranium mill and resulting mill tailings in the City of Monticello, Utah. They further requested that a dose reconstruction be developed to aid in assessing the past exposures of the residents of Monticello.

Radioactive materials and heavy metals in soil and groundwater in the city of Monticello and surrounding area came from the U.S. Department of Energy (DOE) Monticello Mill Tailings Site (MMTS) and Monticello Vicinity Properties (MVP) National Priorities List (NPL) sites. The MVP was added to the EPA's NPL on June 10, 1986 and the MMTS was added on November 21, 1989. The MVP was removed from the NPL on February 28th, 2000. In 1997, the EEP conducted a PHA for the MMTS and MVP.

For this PHA, the EEP reviewed new data from groundwater, surface water, air and food chain samples to better quantify the contaminants of concern and to determine if public health hazards exist in the community. The objective of this PHA is to evaluate the remediation activity at the MMTS and identify any additional public health actions that should be taken based upon data collected since 1997. Ultimately, this assessment provides conclusions on the public health issues relevant to the community and makes recommendations to protect the health of residents in the area. The 1997 PHA identified the greatest risk to the public as exposure to radioactivity from unremediated soils in Montezuma Creek Canyon followed by a potential food-chain pathway from game animals consuming contaminated waters of Montezuma Creek and their subsequent consumption by those who harvest those animals.

BACKGROUND

Land Use and Demographics

The City of Monticello is located at the base of the Abajo Mountains in the Manti-La Sal National Forest. Monticello serves as the county seat and is the second largest city in San Juan County (Map 1). It is also the location of Bureau of Land Management, National Forest Service, and Soil Conservation Service branch offices. The city has a growing tourism industry from nearby Canyonlands National Park and Arches National Park. There are many recreational opportunities in the area, including hiking and hunting in the Abajo Mountains and fishing in several nearby lakes.

Land use within the MVP includes residential neighborhoods, a central commercial district, municipal offices, churches, parks, schools, and light industry. Natural resource use in the area includes domestic water provided by the City of Monticello from a source in the Abajo Mountains. Local groundwater usage includes rural drinking water and limited farmland irrigation from bedrock aquifers. Some surface water is used for crop irrigation. Much of the land surrounding Monticello is rural open range or ranchland, or is cultivated for dry-land farming. Montezuma Creek runs east from the Abajo Mountains and separates the Monticello Mill Site from the city of Monticello. A recreational park runs along both sides of the Creek and is a wilderness restoration area.

As of the 2009 Census estimates, the City of Monticello has a population of 2,212. The median age of residents in Monticello is 30.9 years (vs. 27.1 years for the state of Utah). The median income for Monticello is $38,301, with 9.9% of the population below the poverty line. Of the residents in the City of Monticello, 87% are high school graduates or higher with 20% of the residents having earned a bachelor’s degree or higher. In the City of Monticello 74.5% of the population are White, 0.8% are American Indian and Alaskan Native, 4.4% are Asian, 12.4% are Black or African American, and 7.0% are listed under other race, a compilation of all other races in Monticello. 15.1% of the population identifies itself as Hispanic or Latino (of any race). Nearly 79% of the homes in Monticello are owner-occupied (Census, 2009).

Site History

The MMTS is a 110-acre former uranium and vanadium processing mill adjacent to the City of Monticello. The MVP are off-site residential and commercial properties located within or near the City of Monticello. The U.S. DOE owned the MMTS sites until 2000; when the City of Monticello was given the land through the National Park Service. The City of Monticello, private residents, and the state of Utah own various surrounding properties. No residences are located on the MMTS; however, residences are located adjacent to the north and east edges of the MMTS.

The Monticello Mill was built in 1942 by the Defense Plant Corporation. The U.S. Atomic Energy Commission (AEC) took over operations in 1948. Milling operations ended on January 1, 1960. During operation, the mill processed 900,000 tons of ore. The ore-buying station remained open until March 1962. The mill tailings were stabilized by grading and covering with dirt and rock between 1961 and 1962, and the mill building was dismantled in 1964. The entire mill site was dismantled by 1965. Contaminated soils from the ore buying station were removed and the mill's foundation was demolished and buried in 1974 and 1975. A fence was constructed around the perimeter of the mill site to restrict public access. Beginning in 1971, the U.S. AEC conducted radiological surveys of Monticello to determine the extent of contamination.

Because these properties, and the former millsite, did not meet the legislative requirements for clean up under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), DOE, under the authority of the Atomic Energy Act of 1954, initiated the Surplus Facilities Management Program (SFMP) in 1978 to ensure safe caretaking and decommissioning of government facilities that had been retired from service but still contained radioactive contamination. In 1980, the Monticello project was accepted into the SFMP for remedial action, and the Monticello Remedial Action Project (MRAP) was established to conduct those remedial actions. As owner and past operator of the site, DOE was identified as the potentially responsible party and tasked with funding and performing the remedial actions necessary to ensure protection of human health and the environment into the future.

In 1983 the MVP were established as a separate remediation area from the MMTS. The MMTS and the MVP were added to the CERCLA NPL in 1989 and 1986, respectively. The first CERCLA 5-year review was completed in 1997. In 2012, the fourth CERCLA 5-year review was completed. The latest review concluded that remedies instituted by the DOE were protective of human health at all MVP sites. The MVP was removed from the NPL on February 28th, 2000 (DOE, 2011a).

Summary of Original PHA Findings

In 1995, the Monticello Vicinity Properties Project Site Boundary Program was implemented to provide landowners with the opportunity to identify and remediate properties with mill site-related contamination within and outside of an 8-mile radius of the MMTS. All property owners within this radius were sent certified letters. Public notices were published. Radiological surveys were available to property owners within the 8-mile radius. Property owners outside the radius with evidence of materials from the mill site on their properties could also be surveyed.

In 1997, the first Monticello PHA was conducted by ATSDR. That PHA determined that the MMTS was a public health hazard due to the amount and concentration of radioactive tailings that were present at the site. Although public access to the site was restricted, other contaminant pathways existed due to the intentional usage of radioactive mill tailings throughout the City of Monticello. These pathways of contaminant exposure include tailings used for fill or other

construction purposes and subsequent migration of those transported tailings by wind or surface runoff.
This PHA found that remediation of the vicinity properties was ongoing and scheduled to be completed in 1998. The DOE, EPA and the UDEQ remained committed to remediating all 424 vicinity properties in Monticello to reduce radiation exposure. Remediation was completed in June 1999.

Environmental sampling indicated that the shallow alluvial aquifer contains contaminants originating from the mill site. This raised concern for the much deeper Burro Canyon Aquifer, which has been used as a drinking water source for the city. The EPA, UDEQ and DOE determined that the Mancos Shale and Dakota Sandstone Formations acts as an aquitard and restricts the downward migration of contaminants from Montezuma Creek and the shallow alluvial aquifer into the Burro Canyon Aquifer. Further investigations showed that the contamination in the shallow alluvial aquifer did not present a current public health risk because this source was not being used as potable water. ATSDR concluded there was a potential for future exposure still existed for anyone using the shallow alluvial aquifer as a drinking water source.

Contamination found in the soil as well as surface and groundwater represented a potential for contamination of game and farm animals in the vicinity of the MMTS and Montezuma Creek area. Although no conclusive studies existed at the time the 1997 PHA was finalized, preliminary studies indicated that little or no contaminant uptake in cattle or deer was likely. Another reported exposure pathway of concern involved the ingestion of food crops grown in contaminated soils in and around the city.

In addition, to better quantify the contaminants of concern and pathways of potential exposure, the 1997 PHA also reviewed cancer mortality in the City of Monticello. This analysis identified a 395% increase in tracheal, bronchial, lung and pleural cancer deaths in white males in Monticello in two different time periods (1950-1959 and 1970-1979) when compared with rates for the U.S. population during the same time period (ATSDR, 1997). Tracheobronchial lymph nodes are the site of greatest concentration for inhaled uranium and thorium; both are contaminants found at the MMTS. Increased mortality rates for prostate cancer (males) and breast cancer (females) were also noted. Finally, renal failure in females was also significantly increased in San Juan County as compared to other Utah counties.

A summary of the recommendations made in the original ATSDR PHA, including the agency responsible for implementing each and the status of their progress, can be found in Table 7 of Appendix C.

As part of the detailed Public Health Action Plan (PHAP) outlined in the original document, each stakeholder agency was responsible for performing a specific part of the plan. Upon completion by all agencies, the remediation would result in effective removal of all contamination from the City of Monticello, as well as provide health education and an improved quality of life for residents possibly?exposed to radioactive contaminants from the mill. A detailed summary of the PHAP from the original PHA, including the status of all actions, can be found in Table 8 of Appendix C.

Site Remediation Plan and Completed Remediation

For the MVP, remediation began with radiological surveys, initially in 1971, to identify the nature and extent of radiological contamination associated with mill tailings from the Monticello mill site. These initial surveys identified 98 contaminated properties. Continued surveys ultimately identified 424 contaminated properties in the residential and commercial area of Monticello ("vicinity" properties) and 34 properties on rural land surrounding and downstream of the mill site ("peripheral properties") (DOE, 2007a).

Because these properties, and the former mill site, did not meet the legislative requirements for clean up under the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA), DOE, under the authority of the Atomic Energy Act of 1954, initiated the Surplus Facilities Management Program (SFMP) in 1978 to ensure safe caretaking and decommissioning of government facilities that had been retired from service but still contained radioactive contamination. In 1980, the Monticello project was accepted into the SFMP for remedial action, and the Monticello Remedial Action Project (MRAP) was established to conduct those remedial actions. The DOE was identified as the potentially responsible party and tasked with funding and performing the remedial actions necessary to ensure protection of human health and the environment into the future (DOE, 2007a).

In 1983, remedial activities for the vicinity properties were separated from MRAP with the establishment of the MVP (vicinity properties) and the MMTS (former mill site and peripheral properties). The first two vicinity property removal actions were initiated in 1983 by EPA and completed in 1984. The MVP was listed on the NPL on June 10, 1986, and the remaining properties were remediated pursuant to *MVP Project Declaration for the Record of Decision* (ROD) *and Record of Decision Summary*, November 1989. The Remedial Action Report for operable unit (OU) A, documenting construction complete status and attainment of cleanup goals, was signed into effect in January 1997. Remedial Action Reports for OU B to OU H were signed into effect in July 1999. Deletion of the MVP from the NPL became effective February 28, 2000. Remediation of the MVP site was completed in 1999 (DOE, 2007a).

Cleanup of the MVP consisted of excavating tailings, ore, and related byproduct material from vicinity properties; temporary storage on the Monticello mill site; and final disposal in a repository to be constructed for materials from the Monticello mill site. Because mill tailings from the site were used previously for construction, cleanup included demolition of contaminated sidewalks, patios, sheds, and other improvements. Affected properties were backfilled, graded, and reconstructed. Approximately 150,000 cubic yards of contaminated materials were temporarily placed on the mill site and ultimately disposed of with contaminated mill site material. Radon sampling was completed following property remediation as a requirement for a Property Closeout Report by the U.S. DOE. Cleanup of the MVP was completed in June 1999. A total of 424 properties were ultimately remediated under the MVP project. The MVP site was deleted from the NPL on February 28, 2000 (DOE, 2011a)

The MMTS was placed on the NPL on November 21, 1989. In January 1990, DOE completed the Remedial Investigation/Feasibility Study (RI/FS)-Environmental Assessment (EA) for the mill site. Information provided in the RI/FS-EA enabled DOE to assess the impacts of the remedial action alternatives as required under the National Environmental Policy Act.

Consequently, the MMTS ROD (*Monticello Mill Tailings Site Declaration for the Record of Decision and Decision Summary for the Record of Decision*, August 1990) was signed into effect in September 1990, selecting the remedy for remediation of OU I and OU II; and, designating OU III to address contaminated surface and ground water, and soil contamination in the narrow floodplain in the Montezuma Creek canyon. OU III soil and sediment contamination was later incorporated into the OU II remedy for more efficient management. MMTS remedial actions for OUs I and II conducted under CERCLA began in 1992 and continued through closure of the repository in July 1999. The MMTS was partially deleted from the NPL in October 2003. The remaining MMTS properties are not eligible for deletion from the NPL until the contaminated ground water meets the OU III remediation goals for water quality (DOE, 2007e).

Cleanup of the MMTS surface soil and air pathways was separated into the two previously mentioned operable units (OU I and OU II). OU I consists of the 78-acre former mill site, tailings impoundment areas on the mill site, and storage areas on the mill-site property that were used to store tailings-contaminated materials removed from the vicinity properties and peripheral properties. Construction of a permanent, onsite disposal cell and its leachate collection system is also included in this OU. Components of the OU I cleanup remedy include relocating contaminated materials from the mill site to the disposal cell, revegetation after removal of the tailings, realignment of Montezuma Creek, and reestablishing wetland areas (DOE, 2011a).

OU II consists of 33 private properties and one former DOE-owned property peripheral to the mill site contaminated by windblown tailings and by soil and sediment transported and deposited downstream in and adjacent to Montezuma Creek. Twenty-two peripheral properties, consisting of properties that were not affected by contaminated surface water and groundwater, were deleted from the NPL in October 2003. Deletion of the remaining peripheral properties from the NPL is dependent on meeting the remediation goals for OU III surface water and groundwater that runs through or underlies these properties (DOE, 2011a).

DOE Long-Term Surveillance and Maintenance

The DOE Long-Term Surveillance and Maintenance (LTSM) activities at the Monticello project sites began on October 1, 2001, under the DOE Grand Junction Office LTSM Program. This program provided stewardship to DOE sites with no ongoing activities that contain low-level radioactive materials. The LTSM Program was tasked with establishing compliance with applicable regulations, licenses, and agreements that ensured disposal sites would remain protective of human health and the environment. The LTSM activities were implemented through the LTSM Program in accordance with the Monticello Long-Term Surveillance and Maintenance Administrative Manual (DOE, 2007b). In December 2003, all activities formerly conducted under the LTSM Program, including those for the Monticello NPL sites, were transferred to the newly established DOE Legacy Management (LM) program.

Administration of the MVP and MMTS, as well as LTSM activities for these sites, are presently conducted in accordance with Long-Term Surveillance and Maintenance Plan for the Monticello NPL Sites, June 2007 (DOE, 2007a).

The major ongoing LTSM activities include (DOE, 2007a):

1) Monitoring the leachate collection and leak detection systems at the tailings repository to verify the integrity of the liners.

2) Monitoring the tailings repository cover for erosion, deterioration, settlement, and plant health.

3) Maintaining mechanical systems, monitoring instruments, equipment, fences, storm water controls, signage, and monuments.

4) Responding to public and municipal inquiries.

5) Providing radiological control during any work pertaining to street and utility excavations in the City of Monticello, and managing the disposition of radioactively contaminated materials encountered to the temporary storage facility located at the DOE repository.

6) Surveillance of supplemental standards properties for erosion or disturbance of soils and verifying no unauthorized construction or use.

7) Conducting radiological surveys to support construction of habitable structures where such construction is allowed and such surveying is required.

8) Surveillance of the MMTS to ensure compliance with the requirements of the land transfer to the City of Monticello.

9) Annual verification of institutional controls to ensure continued protection of human health and the environment.

Currently, two full-time employees are stationed at the site to conduct and oversee all LTSM activities (DOE, 2007a).

Progress since Last Five-Year Review

The third CERCLA five-year review of the MMTS was conducted in 2007. Operable Unit (OU) I and II had attained construction complete status by that time. In May 2003, control of OU II and many of the surrounding properties was transferred to the City of Monticello. At that time, closeout reports documenting the completion of compliant remediation had also been approved by EPA and UDEQ for all OU I and OU II properties that did not have groundwater contamination. Since 2002, the major MMTS activities other than routine LTSM have focused on selecting the OU III remedy, resolving MMTS restoration concerns, and finalizing OU I and OU II remedy components.

A final remedy for OU III surface water and groundwater was selected in August of 2004. Institutional controls to prevent the use of contaminated groundwater are currently in place. A comprehensive protectiveness statement for the MMTS cannot be made until the effectiveness and protectiveness of the OU III remedy for ecological receptors can be determined. Ecological studies are ongoing. All aspects of the MMTS remedy (tailings removal and impoundment, revegetation of the area, realignment of Montezuma Creek, and reestablishment of wetlands) have successfully eliminated exposure pathways between the community and the site contaminants. Therefore, the MMTS remedy was designated as protective of human health in the five-year review.

In addition, the following milestones have been completed or accomplished since 2002:

1) Both the MMTS and MVP are administered under DOE-LTSM as of October 1, 2003;

2) MMTS non-groundwater impacted properties were deleted from the NPL on October 14, 2003;

3) Zoning Ordinance 2003-2 was enacted April 23, 2003, by the City of Monticello planning department as an institutional control to minimize exposure to and dispersal of residual uranium contamination in soil at property MP–00211–VL. This action completed the remedy for and OUs I and II;

4) The Record of Decision (ROD) for OU III, surface water and groundwater, was signed into effect in May 2004, which selected monitored natural attenuation with institutional controls as the remedy for surface water. For groundwater, construction of the OU III remedy was completed and was effective in September 2004;

5) Active groundwater remediation and treatment was implemented through the installation of two ex-situ zero-valent treatment cells in 2005 and 2007;

6) Construction of a permeable reactive-treatment wall for groundwater at the MMTS boundary;

7) LTSM activities are conducted under the LTSM Plan for the Monticello NPL Sites, enacted in June 2007, which supersedes previous LTSM documents;

8) The Cooperative Agreement between DOE and the City of Monticello was extended to December 31, 2016;

9) The repository and Pond 4 telemetry system for leachate management was upgraded in May 2007;

10) Broadcast seeding of sparse areas of coverage on the repository was completed in April 2007;

11) DOE constructed drainage controls associated with the repository perimeter drains and channels in 2002 and 2007;

12) DOE continues to monitor selenium concentrations in surface water, sediment and aquifers to establish trends, as concentrations have exceeded benchmark levels;

13) The City of Monticello repaired areas of erosion that were needed at several locations on city property;

14) DOE installed raptor perches and planted shrubs to meet repository vegetation performance criteria;

15) An Explanation of Significant Differences was signed in 2009 that implemented a contingency remedy for OU-3 because the groundwater clean-up was not progressing as anticipated.

DISCUSSION

Nature and Extent of Contamination

The mill tailings at the MMTS contained low levels of radionuclides and several different metals. These materials contaminated nearby properties via wind dispersion, movement of contamination through Montezuma Creek, and using mill tailings as fill for open lands, driveway base, sidewalks, concrete slabs, backfill around water, sewer and electrical lines, and mixed into concrete, plaster and mortar.

Two groundwater-bearing units (aquifers) are located below the MMTS and adjoining areas within the Montezuma Creek valley. The upper unit is the shallow alluvial aquifer consisting of unconsolidated soil, sediment, and rock. The water table is generally 2 to 10 feet below the ground surface. The shallow alluvial aquifer discharges groundwater to and receives surface water from Montezuma Creek depending on location. Both the alluvial aquifer and Montezuma Creek have been contaminated by past MMTS activities. The Burro Canyon aquifer is a deep sandstone aquifer separated from the shallow alluvial aquifer by sandstone and shale in the Mancos Shale and the Dakota Sandstone Formations, which has been determined to be an aquitard, restricting vertical groundwater and contamination movement. The Burro Canyon aquifer is used as a secondary source of potable water (EPA, 1998).

There were numerous alluvial aquifer groundwater contaminants measured in and around the MMTS following the closure of the mill in 1960, including arsenic, molybdenum, selenium, uranium, and vanadium (Carpenter et al., 2000). Contaminant concentrations remained elevated and were reported as such in the 1997 ATSDR PHA (ATSDR, 1997). In the summer of 1999, a zero-valent iron (ZVI) permeable reactive barrier (PRB) was installed down-gradient of the MMTS to remove these contaminants. The reactive portion of the PRB, containing ZVI as the treatment medium, is about 100 feet in length across the aquifer, by 6 feet thick parallel to groundwater flow, by approximately 13 feet deep to bedrock. Low-permeability slurry walls extend out from the PRB to direct groundwater to the reactive zone. The placement of the PRB is shown in Appendix A, Map 2 (Morrison et al., 2006).

In response to excessive mineral precipitation and reduced flow through the PRB, an *ex-situ* treatment system was installed at the PRB in June 2005 to supplement groundwater treatment. Groundwater is pumped from an extraction well located near Well 88-85 through a serviceable cell containing ZVI and gravel. As of June 2006, treated water from the cell is returned to the aquifer by way of an infiltration trench located immediately east of the PRB. With the addition of a second treatment module in March 2007, the total treatment capacity increased to about 12 gallons per minute. Plans to increase the discharge capacity of the trench to obtain full treatment capacity are being developed.

Laboratory and field treatability study results were used to help design the PRB and its reactive material components. Soon after the PRB was operational, an extensive monitoring well network was installed into the shallow aquifer to evaluate the PRB performance (Appendix A, Map 4). Results show that the PRB has been effective in reducing contaminant concentrations over time. Concentrations of arsenic, selenium and vanadium have been reduced to non-detectable levels on the down-gradient side of the PRB. In addition, concentrations of molybdenum have also been reduced to near non-detectable levels. As expected, iron concentrations increase as groundwater passes through the PRB; however, the concentrations are well within the acceptable range (Morrison et al., 2006; US EPA, 2004). In addition, the DOE's 2009 report found that the PRB's ability to transport water has decreased somewhat due to an increase in the mineralization within the barrier. It is estimated that as of April 2009, 10 million gallons of contaminated groundwater had been treated by the ex situ treatment system, resulting in the removal of 23.8 pounds of uranium (DOE, 2009).

Contaminants of Concern

As of December 2011, the following is the list of contaminants of concern (COCs)found in the shallow alluvial groundwaters and surface waters of the Montezuma Creek as determined by the DOE's Office of Legacy Management and the community of Monticello. Detailed tables of sample locations that exceed remediation goals are found in Tables 3,and 4 in Appendix B.

1) Uranium contamination persists in both the shallow groundwaters and surface waters, with concentrations that are in excess of the remediation goal (30 µg/L) and established surface water standards (44 ug/L; EPA, 2004). Uranium contamination extends about 4,000 feet down-gradient of the MMTS (Map 3).

2) Arsenic contamination in the shallow alluvial groundwaters is less than two-times the remediation goal of 10 micrograms per liter (µg/L) and is limited to the area between the MMTS and the PRB. Arsenic contamination in surface waters has only occurred at low levels at Seep 1 which infrequently discharging into Wetlands 3 (Map 3).

3) Manganese contamination is confined to the shallow alluvial groundwaters. Concentrations are as much as eight times above the remediation goal (880 µg/L). The DOE has determined that the likely source of this increase in manganese over previous years is a result of ZVI corrosion during the initial operation of the PRB.

4) Molybdenum contamination is confined to the shallow alluvial aquifer. The concentration slightly exceeds the remediation goal (100 µg/L).

5) Nitrate contamination was detected in both ground and surface waters at concentrations slightly exceeding remediation goals (10,000 µg/L). The likely source of excess nitrate is from nearby feedlots and application of fertilizer during site restoration.

6) Selenium contamination was detected only in surface waters at concentrations above the surface water standard (5µg/L).

7) Vanadium contamination exists only in the shallow alluvial groundwaters. The level of contamination slightly exceeds the remediation goal (330 µg/L).

Sampling the groundwater comprising OU III is accomplished through a network of monitoring wells (Appendix A, Map 4). Sampling wells are divided into five regions, each representing a specific area along Montezuma Creek. Regions 1 and 2 are upstream of the installation of the PRB; Regions 4 and 5 are downstream. Region 3 represents both the area directly prior to the PRB, as well as the area directly past the installation of the barrier. Wells in all regions are sampled at least annually to determine uranium concentrations.

A summary of groundwater by region shows (DOE, 2011):

Region 1	Obvious trending is not evident overall at the wells in this region. This implies a cleanup time that exceeds the established 42-year period. Uranium persists at concentrations between about 100 and 200 µg/L. Only at well T01-19 is a downward trend apparent.
Region 2	All wells exhibit downward trending at rates that project cleanup of this region within the 42-year period, assuming the linear trend continues. Contamination from Region 1 is not expected to impact Region 2 because most of the groundwater in Region 1 is expected to discharge to Montezuma Creek. Uranium concentrations in Region 2 are likely decreasing because the aquifer is locally recharged by uncontaminated water at the eastern end of Wetland 3 and by a losing-stream condition in the reach above the PRB.
Region 3	Three of five wells exhibit a downward trend (wells 92-11, 88-85, and PW-28); the remaining two wells (92-07 and PW-17) show apparent upward trends. The area encompassing wells 92-07 and PW-17 was investigated in April 2009 to evaluate lack of restoration progress in this area (see DOE, 2009). A significant area of uranium contamination was identified in this area south of the creek between the PRB and mill site. Increasing concentration trends at wells 92-07 and PW-17 may reflect downgradient movement of the uranium plume in this area and not continued source input. Trends at wells 92-11, 88-85, and PW-28, which are located north of the creek, suggest that at current rates this portion of the aquifer will attain cleanup within the 42-year period.
Regions 4	Consistent trending is not evident at monitoring locations in this region; instead, concentrations are highly variable over time. Localized upward trending may be expected as groundwater bypass occurs from Region 3 at the south slurry wall of the PRB. Variable concentration trending in this area is also expected because of local irrigation practices and the discharge of treated groundwater from the PRB.

Region 5 Upward trending at well P92-06 may indicate movement of a localized hot spot of groundwater contamination. This result is not unexpected and is due to normal groundwater flow and natural attenuation processes. The remaining wells in Region 5 show no concentration trend. Groundwater restoration in Region 5 will not occur within the 42-year period based on current projections

Exposure Pathway Analysis

To determine if nearby residents, visitors, and workers are exposed to contaminants related to a site, ATSDR evaluates the environmental and human components that lead to human exposure. An exposure pathway consists of these five elements (ATSDR, 2005):

(1) A source of contamination;
(2) Transport through an environmental medium;
(3) A point of exposure;
(4) A route of human exposure; and
(5) A receptor population.

ATSDR categorizes an exposure pathway as either *completed*, *potential, or eliminated*. In a *completed* exposure pathway, all five elements exist and indicate that exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In a *potential* exposure pathway, at least one of the five elements has not been confirmed, but it may exist. Exposure to a contaminant may have occurred in the past, may be occurring, or may occur in the future. An exposure pathway can be *eliminated* if at least one of the five elements is missing and will never be present (ATSDR 2005).

When an exposure pathway is identified, ATSDR comparison values (CVs) for air, soil, or drinking water are used as guidelines for selecting contaminants that require further evaluation (ATSDR 2005). To protect particularly susceptible populations, the CVs for children are used when available.

The potential routes of exposure identified following remediation at the Monticello site are groundwater, and surface water, and the food chain pathways. The contaminant concentrations in these pathways will be discussed.

Eliminated Exposure Pathways

Soil, Air

Following ATSDR's initial health assessment of the MMTS, two completed surface soil pathways (on- and off-site surface soil) and one completed air pathway were identified (ATSDR 1997). These pathways no longer pose a health concern as they were addressed by the remediation activities described above in the Completed Remediation section. It is important to note that although remediation of Vicinity Properties in Monticello has been completed, naturally occurring radon contamination is a statewide concern in Utah.

Groundwater

As of April 2011, uranium remains the most widespread contaminant in the groundwater, with concentrations greater than ten times the remediation goals. Although the mean values collected from all monitored wells exceeds ATSDR comparison values (Table 4 Appendix B), none of the groundwater from the alluvial aquifer is currently being used as potable water for the City of Monticello. The area is monitored by DOE and is not open to the public; therefore, as long as the current monitoring regime is followed that prevents contact with or consumption of the water, groundwater exposure will not occur.

A removal action in the Montezuma Creek flood plain was completed downstream from the MMTS in 1999. Supplemental standards for soil are currently in place, and the Utah Division of Water Rights has placed a restriction on the construction of private wells within the contaminated plume. In 1999, a PRB was completed down-gradient of the MMTS. A full-scale treatability study is ongoing to determine the effectiveness of the reactive barrier to remove contaminants from the surface waters (EPA, 2001).

Potential Exposure Pathways

Surface Water: past, present and future exposure

The surface waters of Montezuma Creek were contaminated with uranium and heavy metals from tailings deposited from the MMTS. These include uranium, arsenic, selenium, vanadium, molybdenum and manganese. In recent years, the remediation activities have limited the site-related surface water contaminants to selenium and uranium.

As part of the monitoring activities accompanying the remediation efforts, surface water from Montezuma Creek was most recently sampled in October 2011 (DOE, 2012). Detections of the following COCs were noted: arsenic, nitrate (as nitrogen), selenium, and uranium. Uranium, selenium, and arsenic were found to be elevated above remediation goals. These results are reported in Table 4 of Appendix B.

Currently, surface waters of Montezuma Creek and Seep 6 are not being used as potable water sources; however, accidental ingestion exposures could result due to recreational usage of the creek. Dermal exposures to contaminants in this pathway for this site were considered non-significant based upon the limited usage of Montezuma Creek (wading only) and the very limited absorption of uranium through skin (ATSDR, 2011). Previous assessments of surface water pathways at similar sites have come to similar conclusions regarding the risks associated with dermal contact to waterborne uranium (ATSDR, 2009a).

Exposure element	Monticello Mill Site
1) A source of contamination………………....	Monticello Mill Tailings
2) Transport through environmental medium...	movement directly into creek water and seeps

3) A point of exposure………………………..	contact with contaminated waters directly or indirectly (i.e., playing in the creek)
4) A route of human exposure……………….…	accidental ingestion of creek water
5) A receptor population……………………...	residents in contaminated area

Complete Exposure Pathways

Food chain: past, present and future

Contamination in the soil and water represent a potential for contamination of game animals and domestic cattle raised in this area and food crops grown in the Montezuma Creek area or irrigated with water from the creek. In 1996, UDEQ and EPA conducted a preliminary study to examine contaminant levels in deer and cattle. The most commonly consumed parts of the animals (edible soft tissues) were tested for concentrations of both metals and radionuclides. The results from the study showed that levels in deer and cattle from the City of Monticello were similar to those in reference animals (Everett et al., 1998).

Another, more in depth study was conducted by EPA to assess the potential for uptake and accumulation of contaminants in cattle allowed to graze in fields directly adjacent to the MMTS contamination and irrigated with water from Montezuma Creek (Graham et al., 2009). This study sampled alfalfa plants, pasture grasses and a composite of both vegetation and irrigation waters used at each of the growing areas. A summary of the study can be found in Appendix G.

The primary source of contamination of plant products is trace amounts of soil on the surface of the plant. Therefore, washing food prior to preparation should be sufficient for removing potential contaminants from food (ATSDR, 1997). The UDEQ and EPA assumed this pathway to be of minimal exposure and therefore did not evaluate contamination levels in plant products/food crops. Based on the data analyzed in the studies referenced above and the lack of sample data exceeding CVs, it was determined that the food chain pathway does not currently present an exposure risk. A recommendation to monitor contaminant concentrations is still essential to determine if contaminants are migrating and are becoming available for accumulation in the food chain.

Exposure element	Monticello Mill Site
1) A source of contamination………………....	uranium and heavy metals in soil and surface water
2) Transport through environmental medium...	uptake by plants or animals (cattle, elk)
3) A point of exposure………………………..	contact with uranium and heavy metals present in food chain
4) A route of human exposure……………….…	ingestion of plants or animal products
5) A receptor population……………………...	residents living in Monticello

Public Health Implications

Levels of contaminants that exceed CV will not necessarily cause adverse health effects upon exposure. The potential for exposed persons to experience adverse health effects depends on many factors, including:

(1) The amount of each chemical to which a person is or has been exposed;

(2) The length of time that a person is exposed;
(3) The route by which a person is exposed (inhalation, ingestion, or dermal absorption);
(4) The health condition of the person;
(5) The nutritional status of the person; and
(6) Exposure to other chemicals (such as cigarette smoke or chemicals in the work place).

The public health implications of the MMTS contamination at the site will be better understood following a thorough toxicological evaluation of the sampling data.

Evaluation Process

The EEP examined the types and concentrations of each COC for each media type (soil, groundwater, air, etc.) in which the chemical was measured. CVs established by ATSDR and EPA were then used to screen for chemicals of concern that would warrant further evaluation for a possible risk to human health. CVs are media-specific concentrations of contaminants that can be reasonably assumed to be harmless when assuming default conditions of exposure. These values are conservative concentrations used to ensure the protection of sensitive populations, most notably pregnant women and children. Values of contaminants that exceed the CVs do not indicate that a health risk exists; it merely indicates that further evaluation is required for these chemicals.

Exposure Dose Estimates and Toxicological Evaluation

Although many of the COCs at the MMTS have been remediated below levels that would cause adverse health effects, there are still some contaminants that are of concern to the community of Monticello. Continued monitoring for many of these contaminants was included in the recommendation section of the original PHA. These contaminants are both radioactive and non-radioactive in nature. Exposure doses for children and adults were calculated and reported below.

The exposure pathways described above were assessed using doses calculated from the highest contaminant levels found associated with each pathway. Exposure doses were then compared with health guidelines. These guidelines are conservative health-protective values that have been developed using human exposure data when it is available from scientific literature. When human data is not available, animal exposure data is used. Health guidelines used in this report include ATSDR's Minimum Risk Level (MRL) and EPA's Reference Doses (RfD). Exposure doses that are lower than the MRL or RfD are considered to be without appreciable risk to human health. If a calculated exposure dose exceeds the health guidelines, the dose is then compared to values from individual studies documented in the scientific literature that have reported health effects. These values may be No Observable Adverse Effect Levels (NOAEL) or Lowest Observable Adverse Effect Levels (LOAEL). If a contaminant has been determined by the scientific literature to be cancer causing (carcinogenic), a cancer risk is also estimated (ATSDR, 2005). The equations for determining exposure dose for oral ingestion and inhalation can be found in Appendix H.

Contaminants of Concern

Uranium

Uranium is a common, naturally occurring radioactive substance that can be found in rock, soil, air and water. Natural uranium is a mixture of three isotopes: ^{234}U, ^{235}U and ^{238}U; although they are all the same chemical substance, they each exhibit different radioactive properties.

Uranium enters water bodies through the breakdown of soil, the erosion of soil and rocks, or the release from processing plants and via ingestion of foods and drinking water. Uranium solubilities and availability for internal absorption will depend on its chemical properties, regardless of its radioactive form. Larger uranium particulates will settle on the bottom of water bodies, increasing concentrations of natural uranium that may already be residing there (ATSDR, 2011).

Uranium is currently detected in groundwater and surface waters creating a potential exposure pathway for incidental ingestion by residents who may come into contact with the contaminated water. All concentrations of uranium detected in this water exceed both ATSDR CV and MRL values if used as drinking water; thus exposure to contaminants in this water could potentially result in adverse health effects and the creek should not be used as a potable water source.

The bioaccumulation of uranium in animals and garden vegetables watered by Montezuma Creek was also a concern. The EPA conducted a bioavailability study to assess the risk from this pathway and concluded that the amount of bioaccumulation was minimal and that no adverse effects would likely be observed from consumption of vegetables, fruit or meats from this area (Graham et al., 2009, see Appendix G).

High levels of uranium exposure,in excess of 2×10^{-4} milligrams/kilogram/day (mg/kg/day) over a year, can cause adverse health effects, including tissue and kidney damage. For comparison, drinking the non-potable waters of Montezuma Creek for a year would result in an exposure roughly 200 times the hazard level. Humans and animals exposed to high levels did not exhibit higher cancer rates. In laboratory animals, high doses of uranium in drinking water resulted in birth defects and an increase in fetal death (ATSDR, 2011).

The current ATSDR drinking water CV for uranium is 30 µg/L. The standard for uranium in drinking water is also 30 µg/L, under the SWDA. The National Toxicology Program (NTP) has not classified uranium in regards to carcinogenicity.

The National Research Council Committee on the Biological Effects of Ionizing Radiation (BEIR) IV Report (NAS, 1988) states that ingesting uranium in food and water at naturally occurring levels will not cause cancer or other health problems in humans. However, based on the zero-threshold linear dose-response model (a conservative model that is intended to be used as an aid to risk benefit analysis and not for predicting cancer deaths), the BEIR IV committee calculated that the ingestion of an additional 1 picocurie/day (pCi/day, 0.0015 mg/day) of soluble natural uranium would lead to a fractional increase in the incidence rate (0.0019) of osteosarcoma (bone cancer). This means that over a period of 70 years (the estimated lifetime length), if everyone were exposed at that level, the number of bone cancer cases in a U.S.

population of 250 million would increase from 183,750 to about 184,100. In the case of Monticello, this would mean an increase of roughly 4 cases over 70 years.

Currently, there are no unequivocal studies showing that intake of natural or depleted uranium can induce radiation effects in humans or animals; however, several chemical toxic effects can be induced in an individual following exposure. These include changes in renal function and cellular toxicity (Lu and Zhao 1990; Zamora et al. 1998, Brugge 2005). The available information on humans and animals suggests that intake of uranium at low concentrations usually ingested by humans or at levels found at or near hazardous waste sites is not likely to cause cancer. The BEIR IV committee therefore concluded that "...exposure to natural uranium is unlikely to be a significant health risk in the population and may well have no measurable effect" (ATSDR, 2011).

The surface waters of Montezuma Creek also contain levels of uranium that exceed CV (table 5 appendix B). The highest concentration was 160 parts per billion (ppb). Though these waters are not used as a potable source, recreational exposures still exist. A dose calculation for uranium exposure, assuming recreational use (40 days/year) and accidental ingestion of ~50 milliliter (mL)/ incident yields a dose of 5.5×10^{-5} mg/kg/day for children and 1.26×10^{-5} mg/kg/day for adults. This is well below the ATSDR intermediate MRL for oral uranium exposure of 2.0×10^{-4} mg/kg/day. Therefore, the EEP concludes that the surface waters of Montezuma Creek under the current usage easements agreed upon by the city of Monticello does not pose a health hazard due to uranium contamination.

Seep 6: Seep 6 is located on the steep south-facing hillside in the northwest portion of the former mill site (see Map 3). Uranium concentration in the waters expressed at Seep 6 remains at about 2,000 µg/L since monitoring at the location began after the completion of mill site remediation in 1998. Exposure dose evaluation indicates that recreational accidental ingestion exposure to uranium in the waters from Seep 6 (5.0×10^{-4} mg/kg/day children) are in excess of the ATSDR intermediate oral MRL (2×10^{-4} mg/kg/day).

The DOE reported that the likely source of contamination is mill tailings or ore present in the backfill of a nearby buried irrigation water line (about 7 ft. deep) or an adjacent, more deeply buried (about 20 ft) sanitary sewer line. The source of water expressed at Seep 6 is suspected to be leakage from the sewer line or the irrigation line.

Flow of water at Seep 6 is low, probably less than 250 mL/min. The water does not flow directly into Montezuma Creek or Wetland 2 but instead seeps into the soil cover immediately down-slope of the seep. The seep is generally perennial and supports a small growth of cattails. Significant wildlife habitat is not supported at Seep 6 because the seep area is less than about 100 ft by 100 ft and the topography is steep.

Radiological contamination in this water utility corridor was left in place during OU II remediation, in consultation with EPA and UDEQ, to be managed by DOE as supplemental standards material consistent with the practices described in *Long-Term Surveillance and Maintenance Plan for the Monticello NPL Sites* (DOE 2007d).

Arsenic

The arsenic present in the City of Monticello is in the inorganic form (ATSDR, 1997). Inorganic arsenic is considered a human carcinogen by the EPA and the International Agency for Research on Cancer (IARC) (EPA, 2006; IARC, 2006). Inhalation of inorganic arsenic has been associated with lung cancer (ATSDR, 2007). Ingestion of inorganic arsenic has been associated with skin, bladder, lung, kidney, liver and digestive tract cancers (IARC, 1980; Schottenfeld and Fraumeni, 1996, EPA, 2006).

A characteristic effect of long-term oral exposure to inorganic arsenic is a pattern of skin changes. These include patches of darkened skin and the appearance of small "corns" or "warts" on the palms, soles, and torso, and are often associated with changes in the blood vessels of the skin. Skin cancer has also been associated with arsenic exposure. Other health effects resulting from ingestion of arsenic include irritation of the stomach and intestines, with symptoms such as stomachache, nausea, vomiting, and diarrhea; a decreased production of red and white blood cells, which may cause fatigue, abnormal heart rhythm; blood-vessel damage resulting in bruising; and impaired nerve function causing a "pins and needles" sensation in hands and feet (ATSDR, 2007). Many symptoms will manifest after years of exposure, depending on individual concentrations and duration of exposure.

From an exposure standpoint, it is possible that residents were exposed to and ingested elevated levels of arsenic when they swam in the tailings ponds when the mill was operational. It is also possible that employees of the mill were exposed to arsenic through the inhalation pathway during mill operations. There has not been any documented evidence of these exposures and it is unknown whether the levels of arsenic in these settings were high enough to cause an elevated cancer risk (ATSDR, 1997).

Due to detrimental health effects that can occur from prolonged exposure to arsenic, federal standards have been implemented to protect human health. In drinking water, the maximum contaminant level (MCL) standard set by the EPA is 10 ppb for arsenic (ATSDR, 2007). In Monticello, the waters contaminated with arsenic are not a drinking water source.

Elevated arsenic concentrations were measured in shallow alluvial groundwater (table 3 Appendix B). As these waters are not currently being used as a potable water source and are not accessible to the community of Monticello, they do not present an exposure health risk at the present time.

The surface waters of Montezuma Creek do not contain elevated arsenic levels (table 4 appendix B); however, Seep 1 (Map 3), contains an elevated level of arsenic above the CV. Dose calculations assuming recreational area usage (40 days/years) and accidental ingestion of contaminated waters (~50 mL/day) yield an exposure dose of 5.84×10^{-6} mg/kg/day for children and 1.34×10^{-6} mg/kg/day for adults. Both of these values are well below the chronic oral MRL for arsenic of 3.0×10^{-4} mg/kg/day.

As arsenic is a known carcinogen, a cancer risk calculation was performed. Assuming an average lifespan of 70 years, the calculated excess cancer risk from arsenic exposure is 2×10^{-6}. The level of total cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, the EPA considers excess cancer risks that are below about 1 chance in 1,000,000 (1×10^{-6} or 1E-06) to be so small as to be negligible, and risks above 1E-04 to be sufficiently large that some sort of remediation is desirable. Excess cancer risks that range between 1E-06 and 1E-04 are generally considered to be acceptable (USEPA, 2012).

Radon

Radon is a naturally occurring, radioactive gas that is odorless and tasteless and occurs in three isotopic forms in nature. Each of these isotopic forms is produced as part of three radioactive decay chains that begin with uranium or thorium. Each atom of uranium or thorium decays about a dozen times, each time expelling radiation and forming a different element with different radioactive properties. Radium and radon are formed midway through these decay chains. The type of radon of greatest concern is Radon 222 which is derived from the decay of radium 226 (from the decay of uranium 238). Uranium 238 is the primary uranium contaminant at this site. The uranium and thorium decay chains ultimately produce non-radioactive forms of lead.

When radon progeny undergo radioactive decay, some of the decays expel high-energy alpha particles, which are the main source of health concerns. Long-term exposure to these particles increases the risk of lung cancer. Exposure to radon and its progeny are considered harmful, causing the US Department of Health and Human Services (DHHS), the IARC and the EPA to classify radon as a human carcinogen (EPA, 2009; ATSDR, 2008b).

Radon concentrations in Utah vary from county to county. Further, there is no distinct pattern of elevated radon concentrations in any given neighborhood. A 2009 Radon Awareness Survey conducted by UDEQ Division of Radiation Control and the Hunstman Cancer Institute concluded that only 12.5% of Utah residents have tested their homes for radon (UDEQ, 2010). In addition, as of March 2011, only 17,483 homes have been tested for radon in the entire state with 178 homes tested in San Juan County. The UDEQ recommends that all Utah residents test their homes for radon. For additional information, readers should visit http://www.radon.utah.gov.

Exposure to radon is the second leading cause of lung cancer in the United States. It is estimated that approximately ten to fifteen percent of lung cancers can be associated with radon exposure (Alberg et al., 2007). Often, these cases are non-smokers. Lung cancer is the leading cause of mortality in Utah. This is of note considering that Utah has the lowest prevalence of smoking in the United States (11.7% vs.19.8%) (CDC, 2009).

Due to detrimental health effects that can occur from prolonged exposure to radon, federal standards have been implemented to protect human health. In 1988, President Ronald Reagan signed into law the Indoor Radon Abatement Act. The EPA recommends mitigation if measured indoor levels of radon are more than 4 picocuries per liter (pCi/L) of air. The EPA also notes that radon levels between 2 and 4 pCi/L may still present a health concern and those living in those homes should consider remediation (EPA, 2010). For additional information from the EPA, readers should visit EPA’s official radon webpage: http://www.epa.gov/radon.

Radon has been a concern of residents of Monticello because much of the contaminated tailings were used in the construction of homes and buildings in the city. Residing within close proximity to these radioactive contaminants could potentially present an exposure hazard. The 1997 PHA recommended that radon measurements should be collected in the vicinity properties to determine if a public health hazard existed, and if so, determine appropriate public health actions. In an effort to quantify the risk posed by this pathway and to determine adverse health effects from exposure, the EEP collaborated with UDEQ to gain access to property closeout reports for the vicinity properties. These reports contained monitoring data for indoor radon that were collected by the U.S. DOE.

Property remediation was performed according to Title 40 Code of Federal Regulations (CFR) §192.12(b)(1). Although these regulations pertain to mill tailings operations, the EPA has determined that these regulations can serve as the guidelines for clean-up of Superfund sites. This regulation states:

> "The objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL [working level]. In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL"(CFR, 1995)

It should be noted that 1 WL corresponds to 100 pCi/L, hence 0.02 WL equates to 2 pCi/L. This annual average standard is the DOE requirement for remediation. While all properties were remediated to the standard required by DOE (DOE, 2007a), a number of remediated residential properties had radon levels that were above the EPA Action Level (4.0 pCi/L). Sampling data from remediated sites is located in Table 6 in Appendix B.

Manganese

Manganese is a naturally occurring metal that is found in rocks and soils. It is silver in color and combines with other substances such as oxygen, sulfur and chlorine. It is used primarily in the production of steel to improve hardness, stiffness and strength. It may also be added to gasoline to improve its octane rating.

In water, manganese tends to attach to particles in the water column or to sediment. The chemical form and type of soil determine how fast it moves and how much is retained through the soil.

Manganese is considered a micronutrient and consuming small quantities of it daily is necessary to maintain health; however, exposure to too much manganese can cause nervous system damage including behavior changes and loss of movement in the extremities. Nervous system and reproductive effects have been observed in laboratory animals following high oral doses of manganese. EPA has concluded that there is not sufficient scientific literature to determine whether manganese is a carcinogen.

Manganese contamination in groundwater is limited to several locations in the center and western part of the MMTS. DOE has determined that the likely source of the increase in manganese concentrations over time is a result of ZVI corrosion from the initial operation of the PRB. Manganese concentrations in the shallow alluvial groundwaters exceed CV (table 3 appendix B); however, these waters are not used as a potable source and access to these waters is not available to the general public. Therefore, the EEP concludes that the shallow groundwater manganese contamination does not pose an apparent public health hazard.

Molybdenum

Molybdenum is an essential trace metal for virtually all living things. Although it does not exist naturally in the metallic state, it combines readily with other elements including oxygen, nitrogen and sulfur compounds. The molybdate anion is the predominant form occurring in soils and natural waters (Fairhall et al., 1945).

Generally, the recommended daily allowance of molybdenum is acquired through foods grown above ground, such as legumes, leafy vegetables and cauliflower. Molybdenum is beneficial to persons with sulfite sensitivity, asthmatics and those intolerant to intravenous sulfur containing amino acids.

As no data is available on the genotoxicity of molybdenum compounds, there is no evidence to support the carcinogenicity of molybdenum. It has not been classified for toxicity by EPA, IARC, The National Institute for Occupational Safety and Health (NIOSH), or OSHA. The World Health Organization (WHO) has established a drinking water standard for molybdenum of 0.02 mg/day (WHO, 1993).

The concentration of molybdenum in the shallow alluvial groundwaters slightly exceeds the remediation goal (100 µg/L) (table 3 appendix B). Molybdenum contamination is confined to one location upgradient to the PRB. No human exposures or health effects are likely at this location.

It should be noted that ruminant animals such as deer and cattle can develop a condition known as molybdenosis due to high exposure to molybdenum. Molybdenosis in ruminants is characterized by loss of pigment around the eyes, and persistent diarrhea. The condition is easily treated by addition of dietary copper to feed. As the background levels in the area are naturally high, so is the expression of molybdenosis in the areas ruminant populations, as such, its presence cannot be definitively related to the MMTS (Graham et al., 2009).

Selenium

Selenium is a naturally occurring metal that is found most commonly in rocks and soil. Selenium is not often found in the environment in its elemental form, but rather combined with other substances. Selenium compounds rarely found in water are very poorly soluble selenium sulfides which bind tightly to soils (ATSDR, 2003). Selenium sulfides are classified as a Class B2 probable human carcinogen by the EPA (EPA, 2011). Selenium compounds found in water are predominantly in the form of soluble salts such selenite and selenate. Exposure to these water-soluble selenium compounds has not been linked to cancer and is considered not classifiable with regards to human carcinogenicity by either the EPA or IARC (EPA, 2012; IARC, 2012). Selenium is an essential nutrient at low doses and may actually have a protective effect against the formation of cancer. Research has shown that selenium has an antagonistic relationship with other certain compounds including arsenic. As a result, most forms of selenium and arsenic interact to reduce the toxicity of both elements (Levander et al., 1977).

The bioaccumulation of selenium was another concern in garden vegetables planted in areas directly adjacent to Montezuma Creek and in animals grazing in fields irrigated with this water. EPA conducted a bioavailability study to assess the risk from this pathway and concluded that the amount of bioaccumulation was minimal and that no adverse effects would likely be observed from consuming vegetables, fruit or meats from this area (Graham et al., 2009).

Though selenium contamination of the shallow alluvial groundwater exceeds the surface water standards set for this site, but do not exceed the CV (table 3 appendix B), these waters are not used as a potable source. Therefore, the EEP concludes that under the current usage restrictions, the selenium in Montezuma Creek does not pose a public health hazard.

Vanadium

Vanadium is a compound that occurs in nature as a white-to-gray metal and is often found in crystalline form. Industrially, it is combined with other metals to make alloys, and used in the production of steel, rubber, plastics and ceramics.

When released into the environment, regardless of the environmental compartment (i.e., soil, air or water) vanadium does not degrade readily; instead, it adheres to sediments and other particles. Low levels of vanadium have been detected in plants, but it is not likely to bioaccumulate in plant or animal tissues.

Exposure to high levels of vanadium in air can cause a wide array of harmful health effects including lung irritation, coughing, wheezing, chest pain, runny nose and sore throat. There is uncertainty in the literature regarding the health effects from the ingestion of the compound. Laboratory animals that ingested high doses have died; however, these concentrations were much higher than concentrations normally detected in the environment (ATSDR, 2009b).

The DHHS and the EPA have not classified vanadium as to its human carcinogenicity as no human studies are available. IARC has classified vanadium pentoxide as possible carcinogenic to humans, group 2B.

Vanadium groundwater contamination exists at six locations between the MMTS and the PRB. The level of contamination at both sites slightly exceeds the remediation goal (330 µg/L). Due to the inaccessibility of the alluvial aquifer, human exposures or health effects are not likely.

Multiple Chemical Exposure Evaluation

The potential for the toxic effects from the chemical mixture interactions of the contaminants at the MMTS were evaluated. The health impact of exposure to chemical mixtures and the potential for combined action of chemicals is a concern and was evaluated using the Hazard Index (HI), which is a summation of the hazard quotients for all chemicals to which an individual has been exposed. To obtain a hazard quotient, calculated exposure doses for individual chemicals are divided by respective MRL or comparison values. If the HI is less than 1.0, it is highly unlikely that significant additive or toxic interactions would occur. If the HI for the chemical mixture at the site is greater than 1.0, the estimated doses for each individual chemical will then be compared to their LOAEL, NOAEL, or comparable values. Doses of chemicals that are less than one-tenth of their respective NOAEL are unlikely to contribute to significant additive or interactive effects with other chemicals in the mixture (ATSDR, 2005).

Calculations used concentrations of contaminants in water samples from October 2011, and included selenium, uranium and arsenic. A summation of hazard quotients for intermittent, accidental ingestion of surface water resulted in a combined HI of 0.295. Based on the calculated HI, it is unlikely that significant additive or toxic interactions would occur from incidental ingestion of surface water.

HEALTH OUTCOME DATA EVALUATION

Health Review

Based upon environmental sampling results collected since the release of the 1997 PHA, there is no indication of exposures to chemical contaminants at levels that would result in adverse health effects (ATSDR, 1997). The installation of a zero-valent iron PRB greatly reduced many contaminant concentrations, resulting in exposures near non-detect levels. In response to community concerns, the EEP reviewed recent environmental monitoring data to assess associations of heart disease, Crohn's disease, Parkinson disease, or neurofibromatosis with exposures to arsenic, molybdenum, selenium, and vanadium. This review found no evidence that any specific chemical/contaminant was linked with any of these specific diseases.

Due to continued concern in the community regarding health effects from past chronic residential exposure to the mill contaminants, the EEP conducted a review of cancer-related mortality data in San Juan County from 1974 through 2006 using additional data available since the original PHA. This report found increasing mortality over time due to lung and breast cancers; however, the development of these cancers is not known to be directly related to exposures to the types of contaminants found at the mill or surrounding site. Additionally, the EEP conducted an analysis of lung cancer mortality in Monticello residents between 1973 and 2006 and found statistically significantly increased odds of dying of lung cancer in the City of Monticello residents as compared to other San Juan County residents; however, many confounding factors, including tobacco use, were not controlled for (UDOH, 2006).

Cancer Incidence Study

The EEP cancer incidence study found evidence of significantly elevated risks for lung and bronchus cancer in residents of the City of Monticello (UDOH, 2006). The significantly elevated outcomes lung and bronchial cancer are consistent with known exposures and are biologically plausible with prolonged exposures to the contaminants from the MMTS (UDOH, 2006) and are also consistent with studies performed at other mill sites (Boice et al., 2007). The limitation of this study was the lack of adjustment for lifestyle factors such as tobacco use, which also are known risk factors in the development of lung cancer.

It has been well documented in the scientific literature that the development of lung and bronchial cancer has been associated with inhaling uranium mill contaminants that include arsenic, beryllium, nickel, chromium, silica, diesel exhaust particles and particularly radon (Boice et al., 2010). No definitive research has linked these cancers with exposure to naturally occurring uranium or uranium ore. A study by Samet et al. (1984) suggested a correlation between lung cancers found in Navajo men, a predominantly non-smoking population, with occupational exposure to uranium mining. Although the study by Samet et al. suggests an environmental link between the exposure and development of disease, it is limited by a small sample size. Larger studies suggest an increased prevalence of lung cancer (UNSCEAR, 2006); however, uncertainties such as worker history and mine conditions make drawing definitive conclusions difficult.

The significant elevations, particularly in lung and bronchial cancer, warrant further investigation and/or continued monitoring; this was the main recommendation of the 2004 cancer incidence study (UDOH, 2006). The next analysis of cancer data will be performed when three more years of cancer data is available (early 2015).

Respiratory Illnesses

The EEP evaluated eight non-cancer respiratory diseases from 1996 through 2006 in the City of Monticello. The respiratory conditions include chronic obstructive pulmonary disease (COPD), bronchitis (not specified - acute or chronic), chronic bronchitis, emphysema, asthma, bronchiectasis, extrinsic allergic alveolitis (EAA), and other COPD (not specified above). The evaluation was based on data obtained from the Office of Health Care Statistics which maintains the Hospital Discharge Database (HDD) and the Emergency Department Encounter Database (EDED). Those data were analyzed using the Rapid Inquiry Facility (RIF) Version 3.11 ArcGIS extension (Jarup, 2004; Beale et al., 2010). The RIF was developed by the Imperial College London with collaboration from the Centers for Disease Control and Prevention and the Utah Environmental Public Health Tracking Network (EPHTN). The City of Monticello was defined as zip-code Census Tabulation Area (ZCTA) 84535. Analyses of cases include both hospitalized and emergency department encounter cases. The comparison population was the remainder of the Utah population. Indirect standardized rates use the Utah 2000 population as the standard population. Expected values for relative risk were derived by direct standardization.

Chronic bronchitis was the only respiratory disease that demonstrated a statistically significant elevation. Chronic bronchitis is an inflammation, or irritation, of the airways in the lungs. Airways are the tubes in the lungs that air passes through, also called bronchial tubes. When the airways are irritated, thick mucus forms in them. The mucus plugs up the airways and makes it difficult to get air into the lungs (Mayo Clinic, 2007).

Unlike acute bronchitis, chronic bronchitis is an ongoing, serious disease. Smoking is the major risk factor, but air pollution, dust or toxic gases in the environment or workplace also can contribute to the condition. Prolonged exposures to certain lung irritants, such as grains or textiles, or exposures to chemical fumes such as ammonia, strong acids, chlorine, hydrogen sulfide, sulfur dioxide or bromine may lead to the development of chronic bronchitis. Chronic inflammation of the airways may lead to asthma (Mayo Clinic, 2007). Table 1 presents the results of the evaluation of respiratory diseases in the City of Monticello.

Table 1. Age-adjusted incidence rates for specific respiratory conditions in the City of Monticello as compared to Utah – 1996-2006.

	Rate (per	**Number of**	**Expected**	**Relative**	**Confidence**	**Confidence**

Time 1996-2006	**100,000 population)**	**Cases**	**Number of Cases**	**Risk**	**Interval Lower Bound**	**Interval Upper Bound**
COPD[1]	569.68	175	162.42	1.08	0.93	1.25
Bronchitis[2]	60.18	46	41.14	1.12	0.08	1.49
Chronic Bronchitis	112.03	_39*_	26.62	1.47	1.04	2.00
Emphysema	3.38	≤ 3	1.72	0.55	0.001	3.25
Asthma	283.95	84	86.94	0.97	0.77	1.20
Bronchiectasis	0	0	0.43	0	0	0
EAA[3]	0	0	0.18	0	0	0
Other COPD	12.11	5	5.40	0.93	0.30	2.16

[1] Chronic Obstructive Pulmonary Disease
[2] Bronchitis (not specified – acute or chronic)
[3] Extrinsic allergic alveolitis
* Statistically significant increase (p = <0.05) from the expected number of cases.
Source: Utah Department of Health, Environmental Epidemiology Program, 2008.

While there was no stratified analysis to examine whether the participants in the study could have been exposed occupationally from working in the mill or from another source (i.e., smoking cigarettes), the smoking rate is extremely low in Monticello (approximately 6%). Also, many participants had worked or were associated with someone who had previously worked in the mill; therefore, to exclude these participants from the study would have yielded unreliable results.

Heart Disease

The EEP also evaluated five non-cancer heart diseases from 1996 through 2006 using the same analytical methods as for the respiratory disease analysis. The heart conditions include ischemic heart disease (IHD), acute myocardial infarction (heart attack), other acute or sub-acute heart disease, angina pectoris (chest pains), and other chronic heart disease.

The incidence of acute or sub-acute ischemic heart disease other than acute myocardial infarction was found to be statistically elevated in the City of Monticello (Table 2). This finding suggests an underlying elevated level of heart disease in the community. The causes of IHD have not been well documented and therefore the contaminants associated with the mill cannot be definitively linked to the development of heart disease.

Ischemia is a condition in which the blood flow (and thus oxygen) is restricted to a part of the body. Cardiac ischemia describes the lack of blood flow and oxygen to the heart muscle. The term 'ischemic heart disease' refers to heart problems caused by narrowed heart arteries. When arteries are narrowed, less blood and oxygen reaches the heart muscle. This is also referred to as coronary artery disease and coronary heart disease. This condition or disease can ultimately lead to a heart attack (AMA, 2001). Approximately 3 to 4 million Americans may have ischemic heart disease without knowing it. These people have ischemia without pain (silent ischemia). Heart attacks may occur without prior warning or symptoms. People with angina, history of heart attack, and diabetes are especially at risk for developing ischemia (AMA, 2001).

Table 2. Age-adjusted incidence rates for specific heart conditions in the City of Monticello as compared to Utah – 1996-2006.

Time 1996-2006	Rate (per 100,000 population)	Number of Cases	Expected Number of Cases	Relative Risk	Confidence Interval Lower Bound	Confidence Interval Upper Bound
IHD[1]	414.74	145	150.37	0.96	0.82	1.13
Acute MF[2]	189.01	64	54.29	1.18	0.91	1.51
Other Acute or Subacute IHD	55.48	18*	10.29	1.75	1.04	2.76
Angina Pectoris	15.11	6	5.11	1.17	0.43	2.55
Other Chronic IHD	155.14	57	80.61	0.71	0.54	0.92

[1] Ischemic Heart Disease
[2] myocardial infarction
* Statistically significant increase (p = <0.05) from the expected number of cases.
Source: UDOH EEP, 2008.

Birth Defects

As part of the PHA, the EEP also evaluated 24 anomalies (adverse reproductive outcomes or birth defects) that occurred in the City of Monticello from 1989 through 2006. These anomalies were tracked by the Utah Office of Vital Records and Statistics as part of the Utah birth record. These data were derived from the birth records from 1989 through 2006.

There were two elevated birth anomalies (with three or more occurrences) found in the City of Monticello; respiratory malformations and urogenital malformations. The birth record does not specify the specific malformation that occurred. Respiratory malformation anomalies include such conditions as choanal atresia, congenital cystic lung and agenesis, and hypoplasia or dysplasia of the lung. Urogenital malformation anomalies include cystic kidney disease, obstructive defects of the renal pelvis and ureter, exstrophy of the urinary bladder, atresia and stenosis of urethra and bladder neck, and other malformation of the urinary system and the reproductive system. Tracheo-esophageal fistula /esophageal atresia (with less than three occurrences) were also reported. Environmental causes (chemical exposures other than alcohol and illicit drug or medications) for urogenital, tracheo-esophageal fistula / esophageal atresia, and respiratory are, for the most part, unknown (PSCH, 2008).

Lifestyle factors such as use of alcohol, tobacco/smoking, illicit drugs, and caffeine and infectious diseases such as rubella, sexually transmitted diseases, radiation (X-rays), and genetics by and from the mother are more likely to cause birth defects than environmental exposures

(PSCH, 2008). There is evidence that uranium exposure may lead to birth defects. For example, an investigation conducted by Shields et al. (1992) in Shiprock, New Mexico showed that infants from mothers who lived near uranium mine tailing piles exhibited a significant increase in birth defects when compared to control births in the same region. It must also be noted that this study also found an increase in birth defects if either parent worked in the local electronics assembly plant; hence the association between adverse pregnancy and exposure to radiation are weak. Most birth defects are abnormalities and have no known causes; therefore, it is once again difficult to correlate specific birth defects with exposure to contaminants associated with the mill facility during operation.

Exposure Dose Reconstruction Feasibility

Dose reconstruction of mill site workers characterizes the environment in which individuals in a community were exposed to radiation using available monitoring or environmental data. Dose reconstruction analyzes the exposure received from facilities that release radioactive contaminants into the environment. When exposures in the environment cannot be fully characterized based on available data, default values based on reasonable scientific assumptions are used (NIOSH, 2008).

The NIOSH Dose Reconstruction Program states that the purpose of a dose reconstruction is “to provide a comprehensive history of site operations, including releases of radioactive material; to provide dose distribution estimates used in epidemiological studies; to provide an independent, comprehensive evaluation of risk; and to provide a baseline for analyzing effects of other activities (e.g., clean-up)” (NIOSH, 2008).

In order to perform a successful dose reconstruction of an area, the following information is required:

1) Retrieval and assessment of historical data from the mill during operation;

2) Development of initial source term and pathway analysis for each contaminant;

3) Calculation of screening doses and relevant pathways of exposure;

4) Development of methods for assessing the environmental doses;

5) Biomonitoring data from individual workers at the mill and residents directly surrounding the mill; and

6) Calculation of environmental exposures, doses, and risks (NCEH, 2008).

The availability and quality of the records is vital in conducting a dose reconstruction. Otherwise, estimating the exposure doses can be difficult. Currently, it is unknown if historical exposure data from the former uranium mill (when operational) exists. This information would include data sheets (e.g., sample mass, activity, or concentration measurement records), logbooks, incident reports, production reports, and safety monitoring.

The results of dose reconstructions may determine the probability that a community's health risks (such as cancer) were elevated due to environmental exposures to ionizing radiation during operations of a facility and continuing until the complete remediation of contaminated property areas. Information resulting from a dose reconstruction can be used as input in epidemiological studies.

The EEP addressed the dose reconstruction concern from the residents by consulting with local experts regarding the feasibility and expertise required for a successful completion of a dose reconstruction. The University of Utah's Rocky Mountain Center for Occupational and Environmental Health, in particular, provided criteria to assess the feasibility and determined what would need to be obtained with regards to document retrieval, finding the location of the documents, categorizing documents once located, accessing documents when the mill was operational and the number of staff that would be needed to retrieve, categorize, assess, the documents and conduct the dose reconstruction.

The cost to determine if a dose reconstruction is feasible (i.e., discovering if the required documents exist and are available) is well beyond the financial resources of the UDOH. Therefore, the EEP will not pursue the process, resources, and expertise to conduct a dose reconstruction in the City of Monticello. The UDOH believes that the current study, in conjunction with the 2006 cancer incidence report, will provide adequate information to the community to address their current and past exposures.

Child Health Considerations

ATSDR recognizes that the unique vulnerabilities of infants and children demand special attention in communities faced with contamination of water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances emitted from waste sites and emergency events. Children are more likely to be exposed because they play outdoors and because they often bring food into contaminated areas. They are also more likely to come into contact with dust, soil, and heavy vapors close to the ground. Also, they receive higher doses of chemical exposures because of lower body weights. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages.

The cancer incidence investigation conducted by the EEP in 2007 attempted to evaluate the incidence of childhood cancers in the City of Monticello. However, between 1973 and 2004, there were three or fewer cases of any cancer in persons between 0 and 18 years old. Due to the small sample sizes, it was not possible to analyze cancer incidence in children separately from adults.

Community Health Concerns

The EEP conducted a Community Needs Assessment in 2006 to evaluate the public health concern associated with potential exposures to contaminants from the MMTS in Monticello, Utah. As part of the process, the EEP staff conducted a site visit, attended town meetings, and distributed a survey. The goal of the needs assessment was to document and respond accordingly to community questions and concerns regarding the spill.

The results of the community needs assessment have been compiled and are presented in this document (see Appendix K). The community will have another opportunity to express concerns during future events held in the community (i.e., public forums and meetings) as well as during the public comment release of this document.

An important concern among the residents is the perceived increase of specific types of cancers including skin, breast, cervical and leukemia. The residents surveyed also reported a range of non-carcinogenic conditions they suspected were caused by living on or near the MMTS, working at the MMTS when it was operational or during the cleanup, or playing on the MMTS property as children. Respiratory illnesses were the most common concern reported. A breakdown of the results of the community needs assessment is presented in Appendix K.

The UDOH has created numerous educational packets for the community that address the specific types of cancers associated with radiation exposure as well as the importance of persistent self-examination and screening programs. Other activities have included quarterly cancer screening programs, cancer workshops in the community, and information regarding the Radiation Exposure Screening and Education Program (RESEP) testing requirements and procedures.

Many resident concerns have been addressed through a series of appropriation funded grants given to the City of Monticello through the offices of Utah Senators Orrin Hatch and Bob Bennett. These grants have been administered through the Health Resources and Services Administration (HRSA), Office of Rural Health Policy, as an outreach-focused special congressional initiative and are a direct result of the grass-roots effort of the community to bring attention to their situation. In 2008, the City of Monticello was given $79,762 as part of the HRSA outreach effort. This funding was used to create cancer screening programs in the community as well as provide health education on the importance of early screening and detection. While the initial funding was used to establish these programs in Monticello, in 2009 the second grant for $377,190 was used to expand the cancer screening program to include limited reimbursement for travel and cancer treatment. This funding has been essential in providing the community with long-term resources needed to provide access to cancer screening resources.

CONCLUSIONS

Past exposures to the radiological contamination and compounds from the former uranium mill site posed a public health hazard to the community of Monticello while the mill was in operation and prior to remediation efforts. However, all of the completed exposure pathways identified in the original PHA have been eliminated or greatly reduced? through active remediation. Previously identified potential pathways of exposure continue to be monitored.

This PHA evaluated and discussed these *potential* exposure routes that include: 1) uranium contaminated groundwater from the Montezuma Creek and surrounding area; 2) surface water contaminated with radioactive products and heavy metals; 3) residential properties with elevated concentrations of indoor radon; and, 4) contamination transfer through the food chain (from soil to livestock to humans or from soil to vegetables grown in gardens to humans) from heavy metal soil contamination.

The shallow alluvial groundwaters beneath Montezuma Creek contain elevated levels of uranium, but current data shows that people are not being exposed to contaminants via this pathway. To ensure the continued protection of public health, groundwater is being monitored and treated to reduce contaminant concentrations and reduce the potential of any future exposures. The EEP concludes that the shallow alluvial groundwater pathway is not expected to harm people's health.

Surface waters of Montezuma Creek continue to contain elevated levels of uranium. The limited usage of these waters precludes hazardous exposures. Therefore, the EEP concludes that although some potential exposure might occur, these exposures are not expected to harm people's health.

The intermittent discharge of groundwater contaminants to the surface through Seep 6 poses a potential health hazard. Accidental ingestion and dermal contact with uranium present in Seep 6 discharges is in excess of the ATSDR MRL. Therefore, the EEP concludes that accidental ingestion and dermal exposure to uranium via Seep 6 surface waters for the foreseeable future could harm people's health.

The concerns regarding transfer of MMTS contamination through the food chain have been addressed by the previously mentioned site-specific studies. Based upon these studies, the EEP concludes that the transfer of uranium and other contaminants from the Montezuma Creek surface waters to the food chain is not expected to harm people's health.

Although exposure to radon through building materials has been remediated, the EPA recognizes that Utah is a state that has the intrinsic potential for elevated indoor radon levels. As such, the EEP cannot currently conclude whether indoor radon levels in Monticello could harm people's health. Although indoor radon in Monticello is not necessarily site related, the EEP recommends that all Utah homes be tested for radon.

RECOMMENDATIONS

Based upon UDOH's review of the updated sampling data to better assess the current exposure situation in Monticello, the following actions are recommended by the UDOH EEP:

1. All Utahns test their homes for radon. This is a standing policy supported by the UDOH and UDEQ. This recommendation is included as it is relevant to the subject matter of this report, but does not suggest that a particular radon hazard exists in the Monticello community. Resources for information and links to discounted radon test kits, provided by the state of Utah are below:
    - The UDEQ's radon information page: http://www.radon.utah.gov/
    - Additional information regarding radon can be found at ATSDR's website: http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=71

- Additional information can also be found at EPA's radon website: http://www.epa.gov/radon/.

2. Individuals with health concerns resulting from possible past exposure to the Monticello uranium mill consult their medical provider.

3. Provide further health education to the Monticello community. Specific areas of education include information on site remediation, indoor air quality (radon), as well as past and current exposures experienced by the community. The EEP will create fact sheets on specific cancers of concern and any other contaminant requested by the community. The educational items will be distributed throughout the community in public buildings and made available on both the VMTE and the EEP website.

4. Consult with the UDOH Native American Liaison to determine if assistance (from the EEP) with health educational activities and information is needed.

5. The DOE, under the oversight of EPA and UDEQ, continue to monitor potential exposure pathways (ground waters and surface waters) to ensure that they do not become a public health hazard in the future.

6. Institutional controls currently in place restricting ground and surface water use should be maintained.

7. Further investigate or monitor cancer rates in the City of Monticello when three additional years of cancer data has been collected by the UCR.

PUBLIC HEALTH ACTION PLAN

The following PHAP will be implemented by the EEP and other government agencies for the community of Monticello. The purpose of the public health action plan is to ensure that the PHA provides a plan of action designed to prevent adverse human health effects resulting from prolonged exposures of the community population to potential hazardous contaminants from the former mill site.

1. The EEP community health educator has completed an environmental health needs assessment of the community and will use this as a guide to address resident concerns. These activities will be used to supplement current health education activities occurring as part of the HRSA grant.

2. The EEP community health educator will provide the community with all available information regarding the site and remediation processes. Informational pamphlets discussing the results of the PHA will be created and delivered to residents of the City of

Monticello, as well as accessible on UDOH's Environmental Epidemiology website (http://health.utah.gov/enviroepi/) following the finalization of the updated PHA.

3. The EEP community health educator will develop or make available from ATSDR educational materials on the health effects of exposure to uranium and its daughter products as well as medical screening and testing for uranium-related diseases. This will include ATSDR's ToxFAQs and Toxicological Profiles for uranium and all radiological daughter products. Relevant information will address all potential media pathways and will be developed in print and electronic format for the general public and health professionals to use as a guide when addressing the health concerns of the community.

4. The EEP will provide residents of Monticello with information regarding indoor air quality and radon testing, including information on how to obtain testing kits at a reduced cost. (http://radon.utah.gov)

5. The EEP health educator will contact the UDOH Native American Liaison to provide assistance and information on a) the site and remediation processes, b) the health effects of exposure to uranium and its daughter products, c) medical testing for uranium-related diseases (i.e., RESEP) and d) the contaminants from the MVP and MMTS, to the Native American populations in the surrounding area of the City of Monticello.

6. Consistent with DOE's long-term maintenance plan, the EEP recommends that the DOE, under the oversight of EPA and UDEQ, continue monitoring potential exposure pathways so that actions can be taken to ensure that they do not become a public health hazard in the future.

7. The EEP will conduct a follow-up HOD review that will evaluate only cancer cases that are specific to the City of Monticello when three additional years of cancer data has been collected by the UCR.

8. The EEP will make the PHA available to the residents of the City of Monticello so that results and implications of this assessment can be discussed with the community and other interested parties.

REPORT PREPARATION

This Public Health Assessment, **Monticello Mill Tailings And Vicinity Properties, Monticello, San Juan County, Utah**, was prepared by the Utah Department of Health's Environmental Epidemiology Program under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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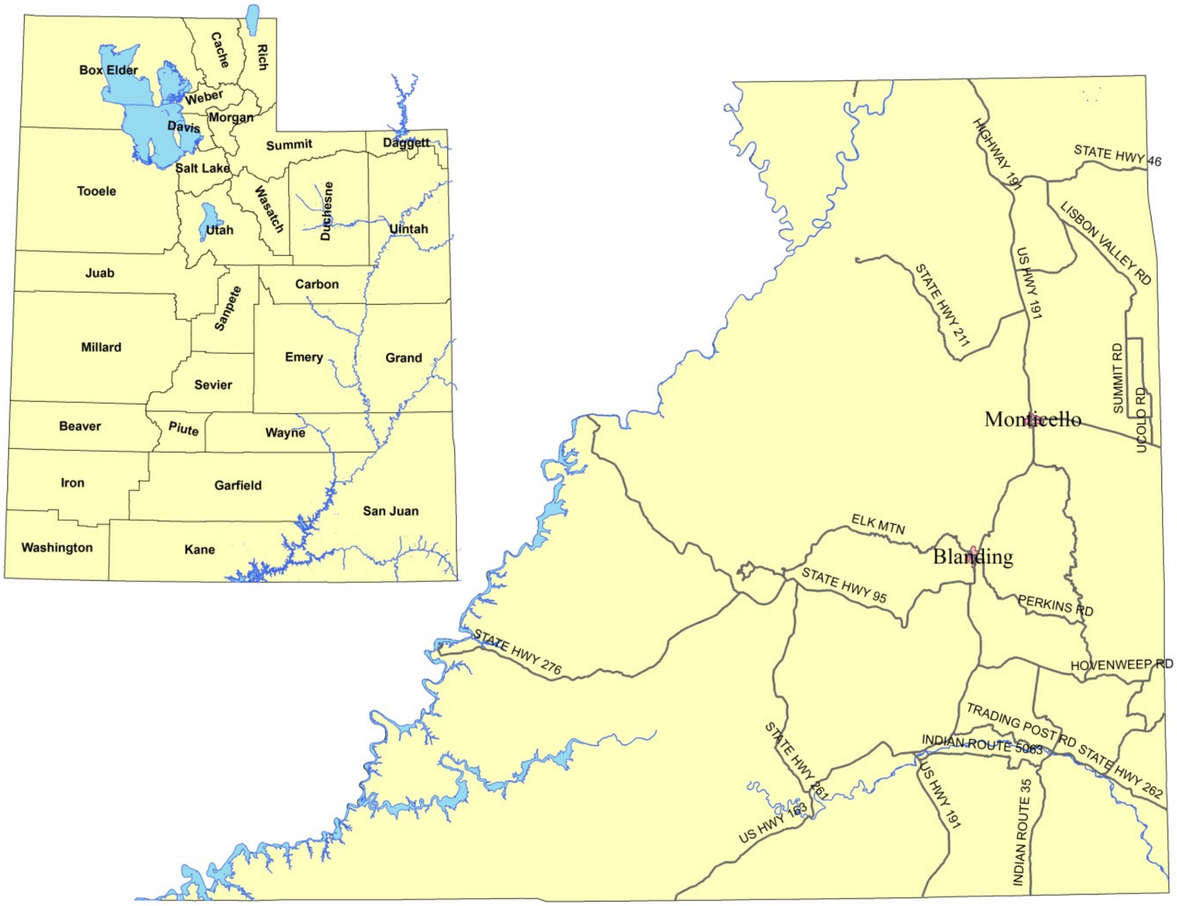
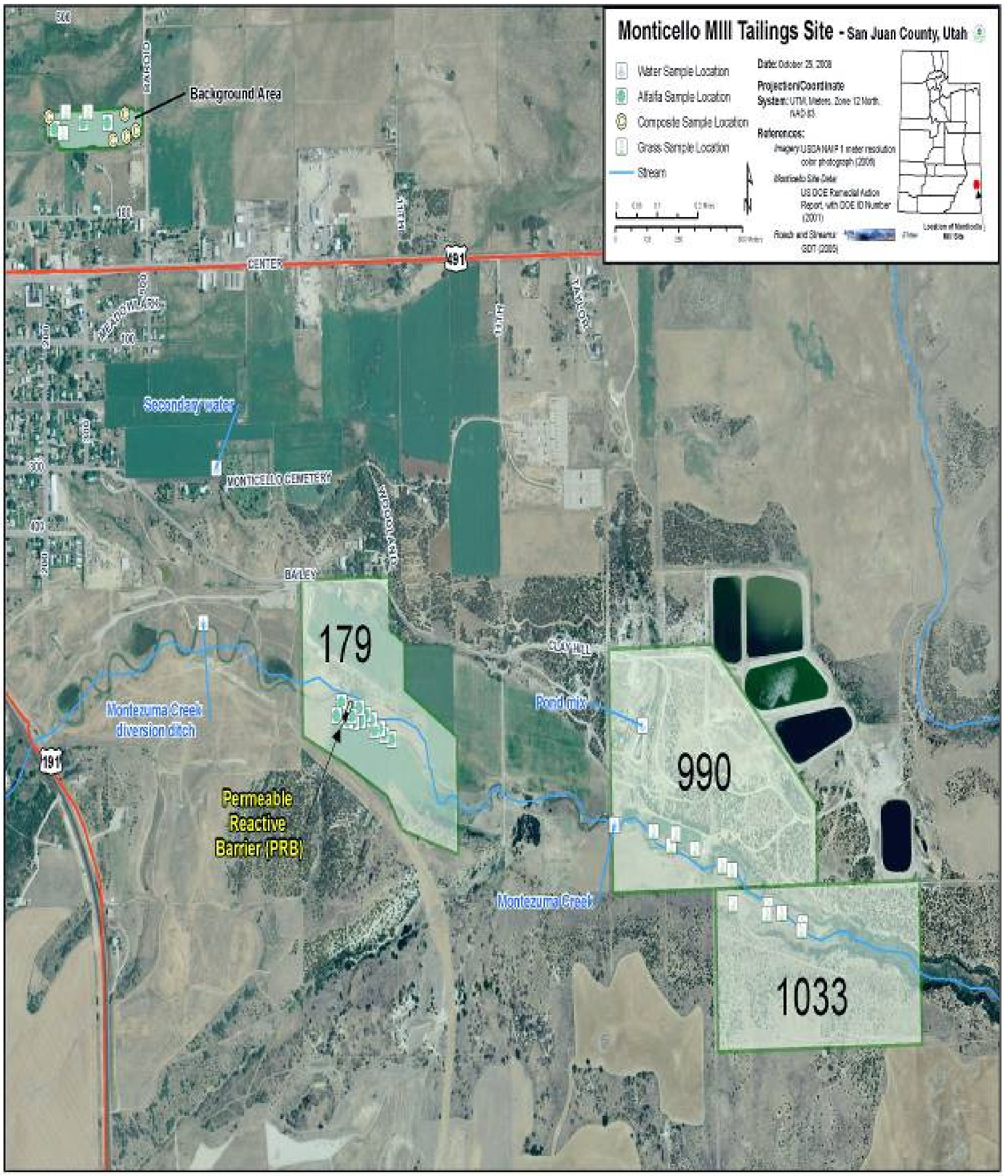
APPENDICES

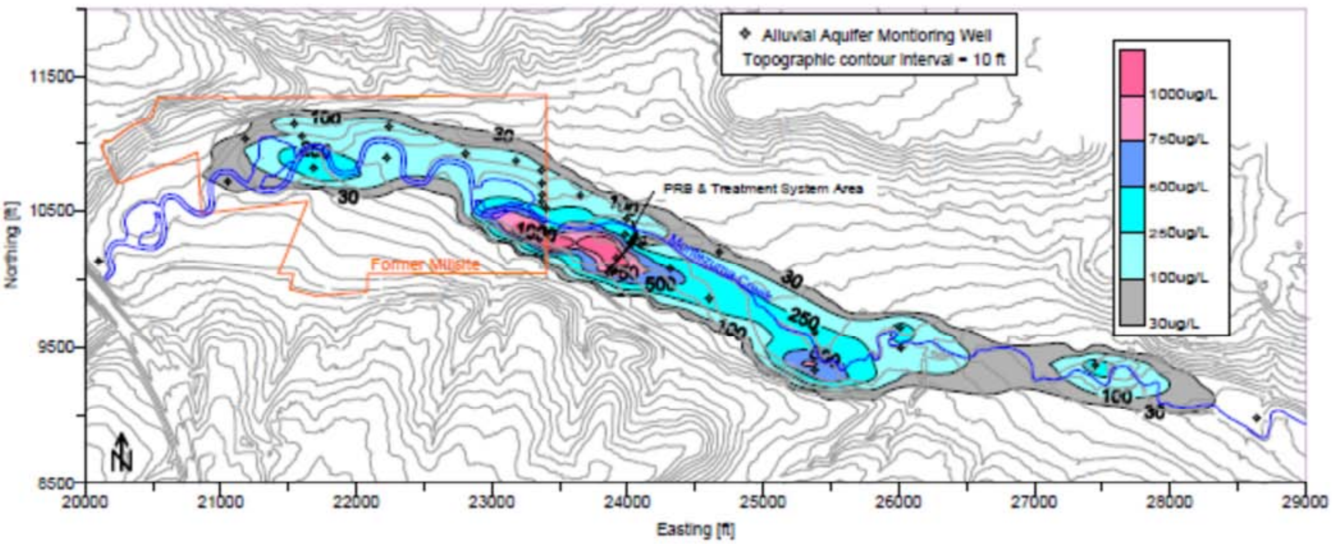
APPENDIX A – MAPS



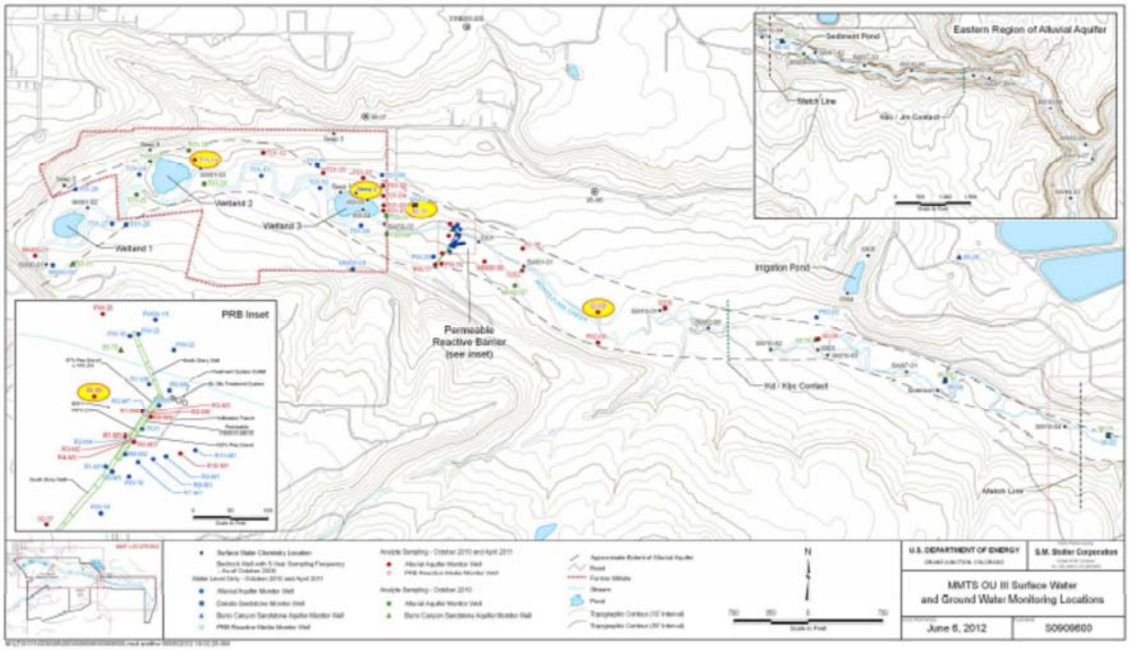
Map 1. State map of Utah, focusing on San Juan County in the southeastern part of the state, where the City of Monticello is located.



Map 2. Monticello Mill Tailings Site. Food-chain study sample locations and Permeable reactive barrier (PRB) location. San Juan County, Utah



Map 3. Delineation of uranium plume resulting from contamination at the MMTS, 2012. The location of the Permeable Reactive Barrier (PRB) is also shown (DOE, 2012).



Map 4. Aquifer regions and monitoring well locations, Monticello, Utah (DOE, 2012).

APPENDIX B – DATA TABLES

Table 3. Monticello Groundwater Locations in OU III that Exceeded Remediation Goals Sample Date: October 2011 (DOE, 2012)

Analyte	Location	Concentration (ug/L)	Remediation Goal (µg/L)	CV (µg/L)	CV Source
Arsenic	88-85	13	10	3	Chonic EMEG (child) ATSDR
Arsenic	92-11	17	10	3	
Arsenic	R1-M3	14	10	3	
Arsenic	T00-04	10	10	3	
Arsenic	T01-01	11	10	3	
Arsenic	T01-02	21	10	3	
Arsenic	T01-04	16	10	3	
Arsenic	T01-05	15	10	3	
Arsenic	T01-13	11	10	3	
Arsenic	T01-25	12	10	3	
Manganese	R6-M3	1,200	880	500	RMEG (child)
Manganese	T01-13	4,500	880	500	
Manganese	T01-18	1,900	880	500	
Manganese	T01-19	6,700	880	500	
Manganese	T01-20	11,000	880	500	
Manganese	T01-25	3,700	880	500	
Molybdenum	PW-17	110	100	50	RMEG (child) ATSDR
Nitrate as +Nitrite	T01-18	11,000	10,000	20,000	RMEG (child) ATSDR
Uranium	200	230	30	30	EPA MCL
Uranium	202	220	30	30	
Uranium	82-08	310	30	30	
Uranium	88-85	240	30	30	

Table 3 (Cont.). Monticello Groundwater Locations in OU III that Exceeded Remediation Goals Sample Date: October 2011 (DOE, 2012)

Analyte	Location	Concentration (µg/L)	Remediation Goal (µg/L)	CV (µg/L)	CV Source
Uranium	92-07	970	30	30	EPA MCL
Uranium	92-08	320	30	30	
Uranium	92-09	360	30	30	
Uranium	92-11	150	30	30	
Uranium	MW00-	720	30	30	
Uranium	P92-06	470	30	30	
Uranium	PW-10	1100	30	30	
Uranium	PW-17	1200	30	30	
Uranium	PW-28	180	30	30	
Uranium	R1-M3	450	30	30	
Uranium	R1-M4	640	30	30	
Uranium	R3-M2	640	30	30	
Uranium	R3-M3	340	30	30	
Uranium	R6-M3	42	30	30	
Uranium	T00-01	66	30	30	
Uranium	T00-04	180	30	30	
Uranium	T01-01	59	30	30	
Uranium	T01-02	170	30	30	
Uranium	T01-04	130	30	30	
Uranium	T01-05	130	30	30	
Uranium	T01-07	140	30	30	
Uranium	T01-12	160	30	30	
Uranium	T01-13	170	30	30	
Uranium	T01-18	450	30	30	
Uranium	T01-19	60	30	30	
Uranium	T01-20	380	30	30	
Uranium	T01-23	38	30	30	
Uranium	T01-35	93	30	30	
Vanadium	88-85	360	330	100	Intermediate EMEG (child) ATSDR
Vanadium	92-07	340	330	100	
Vanadium	92-11	390	330	100	
Vanadium	R1-M3	400	330	100	
Vanadium	T01-02	420	330	100	
Vanadium	T01-04	340	330	100	

Table 4. Summary of Contaminants Present in OU III Surface Water Locations: Monticello, Utah. Sample Date, October 2011.

Analyte	Location	Concentration (µg/L)	Standard (µg/L)	CV (µg/L)	CV Source
Arsenic	Seep 1	17	10	3	Chronic EMEG (child) ATSDR
Nitrate + Nitrite as N	Seep 3	36000	4000	20,000	RMEG (child) ATSDR
Nitrate + Nitrite as N	Seep 5	4700	4000	20,000	
Nitrate + Nitrite as N	Seep 6	4000	4000	20,000	
Selenium	Seep 1	20	5	50	RMEG (child) ATSDR
Selenium	Seep 3	85	5	50	
Selenium	Seep 6	14	5	50	
Selenium	Sorenson	9	5	50	
Selenium	SW00-04	6.9	5	50	
Selenium	SW92-08	5.7	5	50	
Selenium	SW92-09	5.4	5	50	
Selenium	SW94-01	5.7	5	50	
Uranium	Seep 1	260	44	30	EPA MCL
Uranium	Seep 2	160	44	30	
Uranium	Seep 6	1500	44	30	
Uranium	Sorenson	160	44	30	
Uranium	SW00-08	140	44	30	
Uranium	SW92-08	140	44	30	
Uranium	SW92-09	130	44	30	
Uranium	SW94-01	130	44	30	
Uranium	W3-03	160	44	30	

Table 5. COC Concentrations in Burro Canyon Groundwater, October 2006 and 2009 (DOE, 2011)

Well	**COC Concentration October 2010[a]**						
	Arsenic	**Manganese**	**Molybdenum**	**Nitrate[b]**	**Selenium**	**Uranium**	**Vanadium**
CV	***10***	***500***	***50***	***20,000***	***50***	***30***	***100***
83-70	0.1	250	0.95	10U[c]	0.03	0.09	0.03
92-10	0.05	480	1.5	10U	0.03U	0.04	0.01
93-01	0.34	79	0.16	10U	0.03U	0.07	0.14
COC Concentration October 2006[a]							
93-205	31	650	1.4	10U	0.03U	0.16	0.21U
95-06	0.01	450	0.13	10U	0.023U	46	0.21U
95-07	0.7	61	0.13	10U	0.03U	1.1	0.21U

[a] Concentrations expressed as µg/L
[b] Nitrate + nitrite as nitrogen
[c] U = Undetected at listed value

Table 6. Indoor Air radon sampling data from Monticello Property Closeout Reports, 1997.

Sample	**Inclusion Date**	**Report Date**	**Radon Value (pCi/L)***
R1	11/6/1992	1/97	ND
R2	1/31/1991	2/97	0.31
R3	1/31/1991	2/97	1.45
R4	5/1/1992	3/97	3.13
R5	8/2/1993	9/97	0.51
R6	5/12/1992	3/97	0.5
R7	2/21/1991	3/97	1.28
R8	1/23/1991	9/97	0.78
R9	11/6/1992	9/97	2.72
R10	1/27/1984	9/97	2
R11	1/27/1984	9/97	2.65
R12	6/18/1991	3/97	1.77
R13	2/21/1991	3/97	2.67
R14	11/26/1990	3/97	1.65
R15	10/26/1992	3/97	2.09
R16	11/5/1990	4/97	1.84
R17	3/7/1994	4/97	0.46
R18	11/6/1992	4/97	2.12
R19	4/3/1990	4/97	**4.49**
R20	11/1/1996	11/97	0.78
R21	11/27/1996	11/97	1.76
R22	11/27/1996	11/97	ND
R23	1/14/1992	11/97	1.17
R24	11/27/1996	10/97	1.14
R25	11/28/1996	10/97	0.97
R26	10/23/1989	10/97	2.47
R27	1/27/1984	10/97	**6.26**
R28	5/30/1990	10/97	3.85
R29	9/12/1991	9/97	ND
R30	8/25/1995	7/97	0.44
R31	11/29/1993	6/97	2.56
R32	11/6/1992	6/97	0.9
R33	8/2/1994	6/97	3.66
R34	3/29/1989	6/97	**4.39**
R35	11/6/1992	5/97	3.93

Sample	Inclusion Date	Report Date	Radon Value (pCi/L)*
R36	2/2/1993	4/97	3.75
R37	10/7/1988	12/91	**5.06**
R38	5/22/1987	10/91	ND
R39	9/19/1989	9/91	ND
R40	7/16/1990	9/91	ND
R41	3/1/1989	9/91	3.4
R42	2/6/1984	8/91	**4.22**
R43	3/1/1989	9/91	2.76
R44	6/8/1984	8/91	1.9
R55	2/14/1994	7/97	1.81
R56	6/18/1991	2/97	0.87
R57	4/3/1990	2/97	2.97
R58	4/3/1990	1/93	**5.59**
R59	5/12/1992	8/96	0.8
R60	10/23/1989	4/96	1.52
R61	6/8/1984	12/92	2.73
R62	10/23/1989	9/92	**5.08**
R63	10/23/1989	9/92	0.31
R64	10/23/1989	9/92	2.23
R65	10/23/1989	7/92	1.45
R66	1/27/1984	7/92	0.64
R67	6/18/1991	9/95	0.98
R68	6/18/1991	9/95	2.27
R69	11/27/1996	2/99	0.7
R70	11/6/1992	2/99	0.698
R71	3/19/1990	9/97	1.44
R72	6/19/1990	9/97	2.23
R73	6/19/1990	9/97	1.79
R74	2/2/1993	9/97	**6.07**
R75	6/26/1987	9/97	**4.05**
R76	11/6/1992	8/97	1.62
R77	11/1/1996	12/97	1.77
R78	11/6/1992	9/97	1.92
R79	1/25/1990	12/97	1.05
R80	6/8/1984	12/97	ND
R81	8/18/1994	8/99	1.36
R82	11/26/1990	9/97	2.2

Sample	**Inclusion Date**	**Report Date**	**Radon Value (pCi/L)***
R83	11/26/1990	9/97	**4.13**
C1	6/18/1991	3/97	ND
C2	10/10/1991	3/97	0.47
C3	11/6/1992	4/97	ND
C4	1/12/1996	9/97	ND
C5	6/19/1990	4/97	ND
C6	2/11/1992	9/97	ND
C7	1/25/1990	6/97	1.03
C8	11/29/1993	4/97	ND
C9	6/8/1994	6/91	0.4
C10	6/9/1994	6/91	0.93
C11	8/5/1992	2/97	0.74
C12	2/21/1991	12/97	1.22
C13	5/30/1990	8/97	ND
C14	8/18/1994	8/99	0.57
C15	6/8/1994	12/97	ND
C16	5/28/1993	9/97	ND

R= Residential property
C= Commercial building
ND = Non-detect
pCi/L = picocuries per liter
*data in bold indicates a value above EPA Action Level (4 pCi/L)
Source: UDEQ

APPENDIX C – UPDATE ON RECOMMENDATIONS AND PUBLIC HEALTH ASSESSMENT PLAN

Table 7. Status of recommendations from original ATSDR PHA (ATSDR 1997).

Recommendation	Responsible Agency	Current Status	Date Completed
Establish local ordinances to prevent installation in the contaminated alluvial aquifer of wells supplying potable water	City of Monticello	Completed	December 1998
Remediate properties that exceed standards and monitor all properties that have exceeded standards in either of these laws to ensure that remedial actions have removed the tailings	DOE	Completed	December 2000
Monitor wastewater treatment plant effluent to ensure that limits set by the UDEQ, Division of Water Quality are not exceeded	City of Monticello	Ongoing	In Progress
Ensure that residents of Monticello scheduled to have their yards remediated do not consume edible food crops grown in their yards until remediation is completed	City of Monticello	Completed	December 2000
Sample any food crops for human consumption that are grown in the future in the Montezuma Creek floodplain	EPA	Completed; finalized document released.	May 2009
Sample deer and cattle to determine if a potential food chain pathway exists for potential human uptake			
Monitor the shallow alluvial aquifer down-gradient of the MMTS. If site-related contaminants increase to levels of public health concern, initiate a definitive well survey and follow-up monitoring of any private wells identified in the survey	UDEQ	Ongoing; latest sampling results presented in updated PHA	In Progress
Analyze radon measurements collected in the vicinity properties and determine what specific health actions are appropriate. Continue to analyze the radon concentrations that are being released from the tailings piles to determine whether off-site concentrations are at levels of public health concern	UDEQ, with funding provided by EPA	Completed	1997-1998

Table 8. Status of Public Health Action Plan (PHAP) from original ATSDR PHA (ATSDR 1997).

Responsible Agency	Area of Intervention	Recommendation	Current Status
ATSDR	Health Studies	Exposure pathways will be assessed through health studies that will address current and past exposure	Ongoing; the current updated PHA continues to examine and assess relevant exposure pathways
		The occurrence of renal failure will be investigated	Completed as part of UDOH's initial cancer cluster investigation
	Education	Provide community education on adverse health effects to contaminants of concern	Completed; UDOH continues to provide assistance to the community in the form of educational materials and long-term agency support
		Conduct a community needs assessment as a basis for determining the appropriate preventative health education plan for the sites	
DOE	Community Involvement	Establish a Site-Specific Advisory Board (SSAB) to advise on remediation issues affecting the community	Completed May 1996
		Establish a toll-free telephone number for the public to get questions and concerns answered	
	Remediation Activities	Ensure that remediation is completed at each of the 420 MVP sites	Completed; last property remediated in December 1998
		Move contaminated materials from off-site properties to the MMTS and disposed of with the mill tailings in a permanent repository south of Monticello	Completed November 1998

APPENDIX D – SITE CHRONOLOGY

Table 9. Chronology of Monticello Mill Tailings Site Events, U.S. DOE 2007.

EVENTS	DATE
Vanadium and uranium milling processes were conducted at the site resulting in four tailings piles, contaminated soils, contaminated buildings, contaminated processing equipment, and contaminated surface water and groundwater.	1941-1960
Radiological surveys of Monticello properties initiated by DOE, 424 properties identified as contaminated.	1971
Contaminated soils were removed from surrounding ore-storage areas and used as fill material to partially bury the mill foundations.	1965
MMTS was accepted into the Surplus Facilities Management Program to ensure safe caretaking and decommissioning of government facilities that had been retired from service but still contained radioactive contamination. Monticello Remedial Action Project (MRAP) was established.	1980
Two removal actions were initiated in 1983 (and completed in 1984)	1983
Remedial activities for vicinity properties were separated from MRAP and the Monticello Radioactively Contaminated Properties [also known as Monticello Vicinities Project (MVP)] was established.	1983
The MVP was placed on the National Priorities List (NPL).	June 10, 1986
Federal Facility Agreement signed.	December 1988
The Monticello Mill Tailings Site (MMTS) was placed on the NPL.	November 21, 1989
MVP ROD signed.	November 29, 1989
MMTS Pre-Evacuation Final Design Report established an alternate Interim Repository that would be used to store wastes removed from MVP. No Explanation of Significant Differences required for this action.	1993
An ESD was prepared to explain the increase of costs of the project based on the increase of included properties.	April 1995
Operational Unit B to Operational Unit H construction completed	May 1996 to December 1998
Operational Unit A Remedial Action Report	January 1997
First CERCLA 5-Year Review.	February 13, 1997
Explanation of Significant Differences issued to provide the rationale for applying supplemental standards to MVP and MMTS properties in which contamination was left in place.	February 1999
Operational Unit B to Operational Unit H Remedial Action Report	June through August 1999
Operational Unit A to Operational Unit H Final Closeout Report	September 2, 1999
Deletion of the MVP site from the NPL	February 28, 2000
Repository construction completed.	May 19, 2000
Transfer of MMTS to the City of Monticello.	May 2000
MMTS restoration completed (except for vegetation).	July 17, 2000
Remediation activities were completed for MMTS OU I and OU II	2001
MVP and MMTS transferred to LTSM Program	October 1, 2001
Second CERCLA 5-Year Review Report	June 20, 2002
Deletion of 22 MMTS properties from the NPL	October 2003
MVP and MMTS transferred to DOE – LM	December 2003
Remedial action completed for final Operational Unit III – MMTS	June 2004

Source: U.S. DOE 2007a; 2007b

APPENDIX E - OVERVIEW OF RADIATION

Overview of Radiation

In this section, a historical perspective on radiation will be discussed as it relates to human health effects. In the 1890s, scientists learned that certain naturally occurring elements emitted energy known as radiation (1896) and discovered how to produce a specific type of radiation known as X-rays (1895). Soon thereafter, radiation-producing machines and radioactive materials were being developed for use in medical practices, both externally (e.g., to produce chest X-ray images) and internally (e.g., to tag and follow specific enzymes in the body) to diagnose and treat a variety of ailments. Commercial use of radioactive materials followed, resulting in the production and use of numerous products, including electron tubes, static eliminators, smoke alarms and glow-in-the-dark watches. Although radiation and radioactive materials have been used without hesitation for decades for the benefit and enjoyment of humans, this has not been without negative impacts to both the human population and the environment (Mendelsohn, 1996).

Ionizing radiation is energy that is capable of displacing electrons from atoms or molecules, thus producing ions (electrically-charged atoms or molecules). Examples of ionizing radiation include alpha, beta, gamma particles, and x-rays. Radiation produced by radioactive decay typically has more energy associated with it than from chemical reactions. The human body can absorb radiation, although different types of radiation will be absorbed to different extents. For example, X-rays are absorbed by bones, but to a lesser degree by muscle. Ionizing radiation is preferentially absorbed by soft tissues (Shleien, 1992).

Everyone is exposed to ionizing radiation from naturally occurring background sources. Radioactive elements are found everywhere - in air, food, water, and soil. Radioactive gases, especially radon, are the most dangerous, comprising over 50% of background radiation level, while radioactive elements in both the food and soils each contribute about 10% of the background level (NCRP, 2009). Cosmic rays from outer space account for about 10% of background radiation. Exposure from cosmic sources increases when one climbs a mountain or flies in an airplane. Human activities can also increase exposure to radiation. X-rays and other medical techniques that employ radiation and radioactive isotopes can now make up to 48% of a person's annual radiation dose. The average US resident is exposed to nearly six times as much radiation from medical devices than in 1980, according to results from a study completed by the National Council on Radiation Protection and Measurements (2009). Data from this large-scale study of exposure of the US population to radiation concludes that the annual per capita radiation dose has increased 5.9 times, from 0.54 millisieverts in 1980 to 3.2 millisieverts in 2006. The largest radon exposure by far, however, is from cigarette smoking. Smoking has been shown to increase radiation exposure by 400% (Lubin et al., 2007).

The effects of radiation are known to vary from one individual to the next. In order to understand the type and severity of health effects caused by exposure to a specific contaminant, several factors must be considered. These include the amount or dose from ionizing radiation, the frequency and duration of exposure, whether the exposure was external (e.g., medical x-ray, ct-scan, etc.) or internal from eating, drinking or inhaling radioactive material.

The health effects experienced from radioactive contaminants (as it is for non-radioactive contaminants) are also dependent on the personal habits and individual characteristics of the individual exposed, such as age, sex, nutritional habits, health status, lifestyle, and family traits (inheritable risks). All of these characteristics can affect the amount of a radioactive contaminant that is absorbed (the route and amount taken up by the body), metabolized, and excreted (eliminated from the body).

Although the specific effects experienced by each individual are different, general similarities exist. In general, the effects increase with dose, rate, exposure area, age, and internal oxygen concentrations.

In order to provide statistically significant information on health effects from radiation exposure, it is necessary to examine relevant sub-populations that have been exposed to extremely high doses of radiation as a result of occupation exposure, medical treatment, or laboratory studies. The groups considered included uranium miners, cancer therapy patients, atomic bomb survivors and laboratory animals exposed during radiological studies. By examining these sub-populations, a better understanding of the average and range of effects experienced at high doses becomes evident.

Our knowledge of the effects of radiation developed gradually from experiences over the last century. Early in the 1900s many researchers (including Marie Curie) died of cancer, presumably due to exposure from experiments they had conducted on radioactive materials. Occupational exposure to radiation proved to be another opportunity for learning. Uranium mineworkers were exposed to high concentrations of radon gas while working below the ground in mines. Long-term exposure to high concentrations of radon combined with silica, uranium and vanadium dust, diesel exhaust particles and cigarette smoke has resulted in both lung and esophageal cancers in these miners. The actual carcinogens reported in the 11th Report on Carcinogens include silica, cigarette smoke, and radon progeny that adhere to the internal tissue (NTP, 2005).

Numerous lessons were also learned through the study of atomic bomb victims and survivors. The U.S. military dropped the first atomic bomb containing enriched uranium 235 isotopes on Hiroshima, Japan on August 6, 1945 and the second containing plutonium isotopes three days later on Nagasaki, Japan. From the initial blast and subsequent exposure alone, it is estimated that between 150,000 and 220,000 people died, mainly from blast and heat injuries. Over 100,000 of the survivors were enrolled into a monitoring study, which confirmed that an increase in cancer incidence occurred in this sub-population.

Radiation exposure through the use of X-rays has also caused concern, as X-rays were the preferred treatment for numerous ailments, most notably for ringworm in children. Even into the late 1950s, X-rays were used to treat many degenerative bone diseases. In many patients, adverse health effects resulted from radiation exposure from the sources mentioned above (NAS-BEIR VII- Phase 2, 2005).

The adverse effects of radiation on the human body have been extensively studied (NAS-BEIR VII- Phase 2, 2005; Charles et al., 2007; Mettler et al., 2007). Deoxyribonucleic acid (DNA) is a double stranded, helix molecule inside cells that directs the formation of proteins essential to life.

Exposure to radiation or radioactive materials can damage DNA. DNA damage can result in mutations that give rise to cell death or uncontrolled cellular division. Uncontrolled cellular division can result in a tumor or cancer. Mutations would be observed in much higher rates if DNA molecules were not equipped with a repair mechanism. It is only when this repair mechanism cannot salvage the mutation that cell death or uncontrolled cell division occurs.

Although it would be useful to be able to accurately quantify the radiological exposure to the residents of the City of Monticello, reconstructing exposure becomes quite difficult, due to the amount of historical, environmental, and biological data needed. Environmental level effects are often too small to be quantified through direct or indirect measurements, and the source of any particular cancer cannot be determined. Scientists rely on the effects observed in high dose studies and use those values to predict the expected effects following low dose exposure. Often, epidemiologic studies relating health incidence rates of a potentially exposed population to a control population are used. The extrapolation of effects from high dose studies to predict effects at lower doses is assumed to be linear with no threshold, therefore cutting the dose in half would result in a reduction of effects of approximately two-fold and there would be no dose below which no effect is possible.

Determining the ratio between acceptable levels and harmful levels of radiation exposure in humans is complicated. Radiation protection recommendations and regulations were developed to protect the public from excess radiation while still allowing for the beneficial uses of radiation. Many industries crucial to the sustainability of the U.S. (i.e., petroleum, coal, natural gas, electric and healthcare) produce radioactive materials as a byproduct of their activities. The medical community, however, realizes that the potential harmful effects of these levels of radiation is outweighed by the positive benefits of increased cancer regression, decreased need for surgery and more effective diagnoses.

Health effects from ionizing radiation are generally classified into two distinct groups, nondeterministic and deterministic which are based on the statistical probability or certainty that they can be directly attributed to radiological exposure. The nature of how human biological quantities are changed distinguishes between these two types. A short summary of both types of effects is given below, as well as examples of each.

Nondeterministic Effects

Nondeterministic or stochastic[1] effects occur on a random basis independent of the size of the dose. These effects are assumed to have no threshold and the severity of the effect does not vary with dose. Because the effects occur on a random basis, there is no way to predict the individuals that will be affected; therefore, the exposure to radiation can be thought of as increasing the probability that effects will be observed. The likelihood of developing cancer increases with the increased exposure to ionizing radiation. Nondeterministic effects can be compared to buying lottery tickets, in that the more tickets that are purchased, the higher the chances of winning. Similarly, the more radiation one absorbs, the higher the chance of contracting cancer. Contributing factors such as hereditary are considered nondeterministic.

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[1] Stochastic is a form of randomness. With stochastic effects both the random chance of a non-exposed person developing the effect and the random chance of an exposed person not developing the effect are considered.

For example, a person might develop lung cancer from continued years of smoking cigarettes. If the same person had not smoked at all, that person could have still been diagnosed with lung cancer. Conversely, a life-long chain smoker may never develop lung cancer. There is no way to determine whether the cancer is a direct result of the cigarette smoking or just a random occurrence. Using a similar analogy, exposure to radiation does not guarantee that an individual will develop a specific medical condition, although it does increase the chance. Cancer has been linked to radiological exposures and encompasses numerous types including bone, breast, liver, lung, skin, thyroid, cervical, prostate, as well as a variety of leukemia types (Lybarger et al., 1993; Sont et al., 2001).

Present research on human anatomy, coupled with radiation technology has determined that a point mutation in a series of cells in the body can produce a cancerous or mutagenic defect. The cells of the human body are classified into two groups: somatic and germ cells. Somatic cells are those that make up the tissue, organs, and body parts and comprise the largest percentage of cells in the body. Germ cells are used for reproduction and include both sperm and ovum. These cells are rapidly growing and altering in a developing fetus, which makes the fetus as well as growing children more susceptible to radiation exposure. A smaller exposure to ionizing radiation can cause damage to the chromosomes (continuous strands of DNA crucial to human existence), initiating the proliferation of mutagenic cells in the body, which produces cancer.

Another type of cell important to the developing body is the stem cell. Stem cells are precursors to somatic cells. Stem cells are cells that have two important characteristics that distinguish them from other types of cells. First, they are unspecialized cells that have the ability to regenerate rapidly through cell division. Stem cell division can occur through many generations of cells over a long period of time. Second, under certain physiologic or experimental conditions, stem cells can be induced to become cells having a highly important function in the body, such as beating cells of the heart muscle or insulin-producing cells of the pancreas. Stem cells have been shown to help repair or reduce the damage of other specified cells in the body, by enhancing their survival (Chaoxiang et al., 1995). Therefore, the health of these cells is extremely crucial to maintain a healthy balance in the body. Damaged stem cells can result in cancers such as leukemia.

When nondeterministic effects are considered, even the smallest exposure to radiation is assumed to carry an associated risk, and exposure to higher doses of radiation increases the probability of a person acquiring cancer than if no exposure occurred at all. Nondeterministic effects can either be additive, synergistic, or antagonistic. Additive effects are cumulative effects of two or more exposures that equal the sum of their individual effects in isolation. An example of an additive effect is receiving two doses of radiation in a short time period. The total dose received by the individual will be greater than the dose of either individual dose. Synergistic effects occur when the presence of one risk enhances the effects of the second, such as smoking cigarettes and also breathing in radon gas. Synergistic effects occur when the effect of two exposures to be greater than the sum of effects of each exposure individually. Antagonistic effects are those where the total risk is less than the risk observed by the individual parts. Two exposures to radiation with a long period of time between each exposure, allowing ample time for the body to repair any damage caused by the first exposure before the second exposure occurs is an example of an antagonistic effect.

Cancers induced by ionizing radiation are generally indistinguishable from those occurring from other causes. Cancer may be induced in almost all tissues of the human body although the frequency of fatal cancer will vary considerably between the different tissues and organs. Bone marrow is highly sensitive to the leukemia induction. Among organs the stomach, colon and lung are very sensitive while bone, thyroid and skin have low sensitivities. These variations in sensitivity must also be taken into account when calculating the probabilities of cancer induced by ionizing radiation. However, a distinction must be made between cancer incidence and fatal cancer incidence. Lung cancer has, for instance, a very high lethality while thyroid and skin cancers are less fatal. Another important factor is the age of the victim at exposure. Generally, the probability of fatal cancer is higher for people exposed at a young age.

Deterministic Effects

Deterministic effects occur when the severity of the effect varies with the dose and the effects are not seen below a specific threshold of radiation. For deterministic effects, there is a dose below which no effect is observed, but when effects are observed, they depend on the rate at which the dose is absorbed in the tissue. Cells affected by a lower dose of radiation may be repaired or replaced more quickly than those that have been exposed to higher doses of radiation.

Intoxication from drinking alcohol is an example of a deterministic effect. A person consuming some alcohol may appear normal. However, after too many drinks have been consumed, the person will appear intoxicated, perhaps staggering. This is a direct cause-effect relationship- if the person had not consumed too many alcoholic drinks, then the person would not show signs of intoxication.

Deterministic effects include cataract formation, embryonic malformations and neurological effects, skin damage, depression of red blood cell formation and a decrease in fertility, as these effects have both time and quantity thresholds. Individuals exposed to very high levels of radiation in a short period of time show a range of responses. Generally speaking, the more radiation to which an individual is exposed and the faster the exposure occurs, the more pronounced the observed effects will be as well as the sooner they will become evident. At low dose rates, however, adverse effects may not be evident. It is at this point that the dose of radiation exposure is below the required threshold level. The radiation doses experienced by uranium mill workers and populations surrounding mill tailings sites, although not currently known, are considered to be below the threshold level for deterministic effects to become evident. An exposure to uranium, which is a toxic chemical but which has not been found to cause cancer, is another issue to be discussed later.

Radiation Health Effects

The amount of exposure, or dose, dictates whether the effects are deterministic or nondeterministic. Extremely high levels of radiation that are above those encountered from diagnostic medical procedures can or at the levels used in radiation therapy can lead to acute health effects. Acute health effects are characterized by sudden and severe exposure and rapid absorption of the radiation or radionuclide. A single or multiple closely-timed exposures are involved, with a relatively high total dose. Health effects observed due to acute exposures are generally reversible in nature. If an individual continues to be exposed to acute radiation, chronic health effects will be observed. These effects are characterized by prolonged or repeated exposures over many days, months, or years. Symptoms are often irreversible and may not be immediately apparent. In cases of chronic exposure, symptoms may not be diagnosed for some time, therefore delaying treatment. For cancer, a latency period of perhaps 3 to 30 years exists, which allows a lag time to occur between the initial exposure to the source of radiation and the onset of the disease.

The dose of radiation an individual absorbs following an exposure is measured using the conventional unit rad or the International System of Units measurement gray (Gy)[2]. The amount of rads and Gy in various radiation doses is summarized in Table 10 (Cohen, 1993; Pershagen et al., 1994).

Table 10. Summaryof Health Effects from Various Radiation Doses.

Radiation Dose		**Observed Effects (varies with age, gender, and physical condition)**
Gray (Gy)	**Rads**	
0.1-0.5 to fetus in womb	10-50	May cause leukemia or IQ reduction
0.1 to the testes	10	Brief period of sterility
0.25-0.5	25-50	Effects on Blood Cells
1	100	Lowest dose observed to cause leukemia in Nagasaki atom bomb survivors
1-2.5	100-250	Symptoms include nausea and vomiting within hours of exposure, loss of appetite, fatigue, temporary loss of hair in 2-3 weeks and possible death in 1-2 months
2 to the lens of the eye	200	Lens opacity threshold for total dose (not dependent on exposure time)
2-10 to ovaries	200-1,000	Permanent female sterility
5-9.5 to testes	500-950	Permanent male sterility
8.5 to the skin	850	Skin reddening
12 or more	1,200	Gastrointestinal syndrome occurs from desquamation of the intestinal epithelium. The symptoms include nausea, vomiting, and diarrhea almost immediately after exposure,

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[2] There are numerous measurements by which the radiation dose can be expressed. One measurement, known as the rad, was the conventional unit used to express the absorbed dose of radiation. This measurement has been recently replaced by the gray (Gy). The Gy is now the standard measure used by the International System of Units. The conversion between rads and Gy is as follows: 100 rads = 1 Gy. The radiation dose equivalent is measured using a Sievert (Sv), which has replaced the old unit of rem. The conversion between sievert and rem is as follows: 1SV = 100 rem. Finally, radiological activity is measured using a unit called a Becquerel (Bq), which replaces the Curie (Ci). The conversion between becquerel and curie in as follows: 1 Bq = ~ 2.7 x 10^{-11} Ci.

		and death within 1-2 weeks
20-30	2,000-3,000	Permanent hair loss
> 30	> 3,000	Central nervous system syndrome occurs due to damage of the central nervous system. Disorientation and unconsciousness occur within minutes and death within hours to several days.

(Modified from Craig and Jungerman, 1990)

Because symptoms may develop more rapidly after exposure to larger doses, exposed individuals must be aware of any sudden changes in health, as these changes could be indicative of the onset of a disease. Individuals able to identify these symptoms while still in the early stages and who seek treatment early are more likely to be effectively treated. For example, a highly upset stomach can be indicative of total destruction in the cell lining of the gastrointestinal tract. These types of health effects are readily noticeable and identified and are considered deterministic because that the effect observed is directly proportional to the dose. Continued, chronic exposure to relatively high concentrations of radioactive material may produce health effects, although they may not become apparent for years.

Six primary health concerns have been identified for the residents of the City of Monticello. These include: cancer, kidney failure, infertility, degenerative effects, shortening of life span and cataracts.

A large number of studies have been conducted on the health effects experienced by populations following various radiological exposures (NAS 1980). The data collected from these studies show that it is often not the acute health effects that are important, but rather the delayed health effects, which are often more detrimental. Additionally, the background information of the individual may hold numerous keys to explain the effects. Therefore, relevant questions include: Did the person develop cancer?; If so, what type?; How long after exposure did the cancer develop?; Was the source of radiation inside or outside of the body?; and, How old was the person at the time of exposure? The answers to these questions can help to pinpoint the exact time of exposure. There is generally a latency period of 10-15 years after exposure but prior to any observable effects after which a lengthy plateau period follows, where the risk is increased in acquiring a late or delayed health effect. The plateau period may last up to 30 years and the risk of developing cancer during this entire period is constant. Although this is the general pattern seen following exposure, there are exceptions. One exception was noted in the victims of the atomic bombings in both Hiroshima and Nagasaki, Japan. The leukemia that developed as an effect of the extremely high doses of radiation the victims were exposed to was observed within only a few years following exposure (Lamarsh, 1983; Zajtchuk, 1996).

Effects described up to this point have involved high radiation doses and the resulting damage to cell systems. In contrast, high doses of radiation to a single germ cell has been linked to a variety of genetic defects in humans (Russell, 2004; Haines et al., 2006; Rasoulpour et al., 2006), especially if the defect is passed to the next generation. If the dose is received during pregnancy, then the developing fetus could sustain detrimental health effects, including point mutations (mutation that causes the replacement of a single base pair with another pair), multiple point mutations (disorder involving many genes), chromosomal aberrations (disruptions in the normal chromosomal content of a cell, causing major genetic alterations in humans i.e., Down Syndrome), and spontaneous abortions.

Infertility is normally attributed to gamma-ray radiation of the human gonad. For males, a dose of 0.1 Gy received within a short time period (hours to days) may cause temporary sterility, with doses between 5 and 9.5 Gy causing permanent sterility. For females, the doses are much different and can vary according to age. An exposure of between 1.5 and 6.4 Gy causes temporary sterility, with permanent sterility occurring at doses between 2 and 10 Gy (Pershagen et al., 1994).

Chromosomal damage to a single hematopoietic stem cell can result in blood cancers such as leukemia. The induction of leukemia by ionizing radiation is due to the induction of irreversible mutational changes in stem cells during the creation or replication of DNA directly following radiation exposure. Although this type of radiation exposure can be detrimental to the cells, there is research to suggest that this is not the only negative effect; studies examining ionizing radiation have also discovered that not only are the irradiated cells negatively affected, but the radiation has the potential to affect the progeny of these stem cells, which may then express gene mutations and chromosomal aberrations (Wright, 2002).

The doses of radiation in and around the City of Monticello, although not documented, are hypothesized to be thousands of times lower than the values given above (Xintaras, 1992). Epidemiological studies do not report any adverse health effects at doses below 10 rads, even for repeated exposures. This may be a result of the body’s unique defense system and repair mechanisms or that the effects simply cannot be detected.

APPENDIX F -- RADIOLOGIC CONTAMINANTS IN MONTICELLO

Radiologic Discussion

The range of possible health effects from radiological exposures are varied and complicated. The effects experienced depend on the toxicity of the radionuclide, its decay scheme and any associated toxicity resulting from daughter products, the half-life and resulting decay intensity of the radionuclide, the pathway of the radionuclide into the human body, the metabolism, transport, storage, and excretion of the radionuclide while in the human body, and the amount of the exposure (radioactivity). Naturally-occurring radionuclides include primordial radionuclides that have been present in the rocks and minerals of the earth's crust since it was formed. Cosmogenic radionuclides, produced by interactions of atoms in the atmosphere with cosmic rays, are a second source of naturally-occurring radioactive materials. Examples of naturally-occurring radionuclides are uranium, radon gas, and carbon-14.

Radioactive Contaminants and Resulting Health Effects

1) Uranium

Uranium is a natural and commonly occurring radionuclide. Uranium has been around since the earth was formed and has a very long half-life (4.5 billion years), which is the amount of time required for one-half of uranium to break down. It is found in very small quantities in nature in the form of minerals, but may be processed into a silver-colored metal. Rocks, soil, surface and groundwater, air, and plants and animals all contain varying amounts of uranium. Typical concentrations in most materials are a few parts per million (ppm). This corresponds to around 4 tons of uranium in 1 square mile of soil 1 foot deep, or about half a teaspoon of uranium in a typical 8-cubic yard dump truck load of soil. Some rocks and soils may also contain greater amounts of uranium. If the amount is great enough, uranium may be present in commercial quantities and can be mined. After the uranium is extracted, it is converted into uranium dioxide or other chemical forms by a series of chemical processes known as milling. The residue remaining after the uranium has been extracted is called mill tailings. Mill tailings contain a small amount of uranium, as well as other naturally radioactive waste products such as radium and thorium (ATSDR 1999b).

Natural uranium is a mixture of three types (or isotopes) of uranium, written as ^{234}U, ^{235}U, and ^{238}U, or as U-234, U-235, and U-238, and read as uranium two thirty-four, etc. All three isotopes behave the same chemically, so any combination of the three would have the same chemical effect on your body. However, they are different radioactive materials with different radioactive properties. As a result, the radioactivity of uranium is determined by evaluating all three isotopes in a sample. By weight, natural uranium is about 0.01% ^{234}U, 0.72% ^{235}U, and 99.27% ^{238}U. About 48.9% of the radioactivity is associated with ^{234}U, 2.2% is associated with ^{235}U, and 48.9% is associated with ^{238}U (ATSDR, 1999b).

The radioactivity percentages differ because each isotope has a different physical half-life. Radioactive isotopes are constantly changing into different isotopes by giving off radiation. The half-life is the time it takes for half of that uranium isotope to give off its radiation and change into a different element. The half-lives of uranium isotopes are very long (244 thousand years for ^{234}U, 710 million years for ^{235}U, and 4½ billion years for

^{238}U). The shorter half-life makes ^{234}U the most radioactive, and the longer half-life makes ^{238}U the least radioactive. If you have one gram of each isotope side by side, the ^{234}U will be about 20 thousand times more radioactive and ^{235}U will be six times more radioactive than ^{238}U (ATSDR, 1999b).

When a radioactive atom decays, it changes into an atom of another element (called a daughter) and releases radiation. Often, the daughter product is not stable and also decays and releases radiation. This process continues until a stable, nonradioactive daughter is formed. This chain of decaying daughters is called the decay chain. During the decay process, alpha, beta, and gamma radiations are released. Alpha particles can travel only a short distance and cannot travel through the skin. Its effects are limited to the surface tissues. Surface tissues include any tissue that can be directly exposed to environmental contaminates such as skin, the lining of the respiratory tract airways, and the lining of the gastro-intestinal tract. Beta particles can penetrate through the skin, but they cannot go all the way through the body. The effects of beta particles are found in other organ tissues besides surface tissues. Gamma radiation, however, can go all the way through the body and can affect any part of the body. The natural decay of all isotopes of uranium and the daughter products of uranium result in the release of alpha or beta particles depending on the isotope as well as associated gamma radiation (ATSDR, 1990a).

Figure 1: An Example Decay Chain for Uranium-238 and Uranium-234. The illustration below is included to demonstrate a possible pathway for the daughter products in a uranium decay series. This illustration is not indicative of all decay series; decay series pathways for other radioactive isotopes are available on the internet.

NOTES:

The symbols α and β indicate alpha and beta decay, and the times shown are half-lives.

An asterisk indicates that the isotope is also a significant gamma emitter.

Uranium-238 also decays by spontaneous fission.

(Argonne National Laboratory 2005)

The health effects associated with oral or dermal exposure to uranium are not related to the element's radiologic properties but to their chemical ones; there is no definitive research, however, that links these chemical exposures to cancer. The major organ affected by uranium toxicity is the kidney (OHS, 1994). Animal studies have demonstrated that inhalation or ingestion of large quantities of uranium result in the development of kidney disease (ATSDR, 1999b). Although prolonged exposure to uranium can result in adverse health effects or toxicity to specific organs in the body, no human cancer of any type has been linked to exposure to either natural or depleted uranium sources (ATSDR, 1999b). Exposure to many of the decay products of uranium could result in a variety of health effects, including cancer.

2) Radium

Radium is a naturally-occurring silvery white radioactive metal that can exist in several forms called isotopes. It is formed when uranium and thorium (two other natural radioactive substances) decay (break down). Radium has been found at very low levels in soil, water, rocks, coal, plants, and food. For example, a typical amount might be one picogram of radium per gram of soil or rock. This would be about one part of radium in one trillion (1,000,000,000,000 or 1×10^{12}) parts of soil or rock. These levels are not expected to change with time (ATSDR, 1990a).

Some of the radiation from radium is constantly being released into the environment. It is this release of radiation that causes concern about the safety of radium and all other radioactive substances. Each isotope of radium releases radiation at its own rate. Radium-224 releases half of its radiation in about three and a half days; whereas another isotope, radium-226, releases half of its radiation in about 1,600 years. Radium decay includes alpha particles and gamma radiation.

Ingestion of radium has been associated with bone sarcomas and brain cancer. Possible associations with breast, liver and kidney cancers have also been found. The primary exposure of concern for radium is through the oral route via incidental soil consumption, such as when children play outside. ATSDR calculations indicate that radium ingestion in such a setting is insufficient to cause radiation exposure beyond the maximum recommended dose (ATSDR, 1990a).

3) Radon

Radon is a naturally occurring colorless, odorless, tasteless radioactive gas that is formed from the normal radioactive decay of radium. Uranium, the ultimate precursor of radon, is present in small amounts in most rocks and soil. It slowly breaks down to other products such as radium, which then breaks down to radon. Some of the radon moves to the soil surface and enters the air, while some remains below the soil surface and enters the groundwater (water that flows and collects underground). Uranium, radium, and thus radon, will continue to exist indefinitely at about the same levels as they do now (ATSDR, 1990b).

Radon also undergoes radioactive decay and has a radioactive half-life of about 4 days. This means that one-half of a given amount of radon will be changed or decayed to other products every four days. Radon is a gas that disperses quickly outside; however, in enclosed spaces, radon gas can accumulate and may be a health hazard. Both alpha and beta particles are released as a result of radon decay. Exposure to radon in indoor air has been associated with lung cancer (ATSDR, 1990b).

4) Ionizing Radiation

Ionizing radiation is a form of energy like heat and light. It includes particles and rays of “radiation” given off by radioactive materials. Ionizing radiation comes in the form of alpha particles, beta particles, X-rays, and gamma rays. These particles and rays are emitted from radioactive materials as part of the radioactive decay process. The particles and rays carry energy that can disrupt other atoms and molecules such as those in the human body (ATSDR, 1999a).

When radioactive materials enter the environment, they act like other hazardous chemicals in that it can contaminate the air, water, soil, and food while also giving off radiation. Humans can be exposed to ionizing radiation from many sources. Exposure to low levels comes from the sun, rocks, soil, natural sources in the human body, fallout from past nuclear weapons tests, consumer products, and other sources. People in certain professions such as pilots, flight attendants, certain medical personnel, and industrial and nuclear power plant workers have higher exposures to ionizing radiation. Some medical tests and x-rays involve varying degrees of radiation exposure (ATSDR, 1999a).

Overexposure to high amounts of ionizing radiation can lead to effects such as skin burns, hair loss, birth defects, cancer, mental retardation (a complex central nervous system functional abnormality), and death. The dose determines whether an effect will be seen as well as its severity. For some effects such as skin burns, hair loss, sterility, nausea, and cataracts, there is a certain minimum dose (the threshold dose) that must be exceeded to cause the effect. Increasing the size of the dose after the threshold is exceeded makes the effect more severe (ATSDR, 1999a).

APPENDIX G – REVIEW OF STUDIES OF POTENTIAL BIOACCUMULATION OF URANIUM

Uranium Bioaccumulation

Contamination in the soil and water represented a potential for contamination of game animals, domestic cattle, and any food crops grown in the Montezuma Creek area or irrigated with water from the creek.

In 1996, UDEQ and EPA conducted a preliminary study to examine contaminant levels in deer and cattle. The most commonly consumed parts of the animals (edible soft tissues) were tested for concentrations of both metals and radionuclides; the results from the study showed that levels in deer and cattle from the City of Monticello were similar to those in reference animals (Everett et al., 1998).

Another, more complete study was conducted by EPA to assess the potential for uptake and accumulation of contaminants in cattle allowed to graze in fields directly adjacent to MMTS contamination and irrigated with water from Montezuma Creek. (Graham et al., 2009) This study sampled alfalfa plants, pasture grasses and a composite of both vegetation and irrigation waters used at each of the growing areas, as well as background concentrations. Plant, root and soil metal concentrations in the three plots were compared to nutritional guidelines for grazing animals, ecological toxicity screening levels, and predicted human health risk ingestion levels from the consumption of cattle and game meat that graze on alfalfa and grass as well as drink from Montezuma Creek.

Three sample plots were chosen for analysis; Area 179 was composed of alfalfa only, whereas only grass was found in Area 990. A mixture of grass and alfalfa was found in Area 1033; therefore, it was considered a mixed sample. The locations of the three sampling areas are shown in Map 2 of Appendix A. Results from each of the three plots samples are summarized in Table 10 for soil, vegetation and irrigation waters.

Table 10. Sampling Results for Areas 179, 990 and 1033 from the Alfalfa, Grass and Co-located Soils Bioconcentration Study in the Monticello area (Graham et al. 2009).

Sampling Area	Soil and Water Results	Vegetation and Root Results
179	• 15 soil samples collected • 4 metals (Copper, Lead, Uranium and Vanadium) were measured above detection limits • Selenium found in one sampling location at 0.51 mg/kg • Irrigated alfalfa using background water originating from Lloyd's Lake with partial mixing from Montezuma Creek • Water sampled did not have metal levels above ICP-MS detection limits	• Alfalfa sampled in 4 locations up-gradient of permeable reactive barrier and 11 locations down-gradient • Uranium and Selenium were detected in only one alfalfa sample at low concentrations (0.22 and 0.5 mg/kg, respectively) • Copper uptake pre-barrier was 33% higher than post-barrier • Molybdenum showed an equal transfer rate prior to and following the permeable reactive barrier
990	• 4 soil samples collected • 5 metals (Copper, Lead, Uranium, Vanadium and Selenium) were measured above detection limits • Molybdenum and Selenium concentrations were greater than background soils at sampling locations closest to Montezuma Creek and decreased moving inland • Irrigated grass using both water from Montezuma Creek and water from a pond on the property • Uranium was detected in the pond at 117 µg/L; no other metals were elevated	• Only grass was sampled • 2 metals (Selenium and Uranium) were elevated above background
1033	• 8 soil samples collected • Only 1 sample exceeded background concentrations for Vanadium • Irrigated using both Montezuma Creek and pond waters (similar to Area 990)	• Uranium at all sampling locations was greater than background concentrations • Selenium was detected above background in one sample • Transfer ratio for Uranium in Area 1033 greater than Areas 179 or 990 • Other metals show similar transfer ratios as observed in other areas

Uranium concentrations found in the alfalfa vegetative leaves and stems showed uptake above background in only two plants tested: one from Area 179 which was down-gradient of the permeable reactive barrier and one in the background area sampled. Although uranium was found to have transferred into the roots of the plant, the experiment did not differentiate whether the uranium was inside the root cell walls or absorbed onto the exterior walls of the root cells. Studies in the literature suggest that uranium accumulates primarily in the roots with acidic soil pH (less than pH = 5.5). The depth of uranium in the soil may also influence absorption into the plant stems and leaves (Sheppard and Evenden, 1988; Ebbs et al., 1998; Hossner et al., 1998; Echevarria et al., 2001).

Concentrations of the other metals of concern (i.e., copper, lead, molybdenum, selenium and vanadium) in vegetation and root samples were not found to be toxic to either the plant or to the animals grazing on these plants, according to EPA's Eco-toxicity Screening Values. The results from the study suggest that no adverse health effects to cattle would result from the continuous ingestion of alfalfa containing the concentrations of metals found in the soils. Additionally, through the use of transfer coefficients, maximum grass uranium concentrations in cattle and basic human health exposure assumptions, it is unlikely that a typical person consuming meat from cattle grazing on these lands would be exposed to uranium levels exceeding established health guidelines (Graham et al., 2009).

The primary source of contamination of plant products is trace amounts of soil on the surface of the plant. Therefore, washing food prior to preparation, as is standard hygiene practice, should be sufficient for removing potential contaminants from food (ATSDR, 1997). UDEQ and EPA assumed this pathway to be of minimal exposure and therefore did not evaluate contamination levels in plant products/food crops. Based on the data analyzed in the study and the fact that none of the contaminants were detected above CV, it was determined that the food chain pathway does not currently present an exposure issue. However, a recommendation to monitor contaminant concentrations will be essential to determine if contaminants are migrating and are available for food chain accumulation.

APPENDIX H -- EQUATIONS

Exposure Dose (ED) equation for incidental ingestion of surface water ingestion [ATSDR 2005]:

ED = (C x IR x EF) / BW

Where: C = Contaminant concentration (mg/liter)

IR = Intake rate of contaminated water (liter/day)
= 45 mL/day for a child

EF = Exposure Factor; an exposure factor of "0.11" was used for this health assessment (1 represents daily exposure to the contaminant, 365 days per year, whereas in this case, we assume that the child plays in the surface water for 40 days of the year).

BW = Body Weight (kg)
= 16 kg for a child

Exposure Dose (ED) equation for incidental ingestion of soil [ATSDR 2005]:

ED = (C x IR x EF x CF) / BW

Where: C = Contaminant concentration (mg/kg)

IR = Intake rate of contaminated soil (kg/day)
= 100 mg/day for an adult
= 200 mg/day for a child

EF = Exposure Factor; an exposure factor of "1" was used for this health assessment (1 represents daily exposure to the contaminant rather than intermittent exposure. This assumes that the person is spending time in the yard, gardening or playing each day).

CF = Conversion Factor (10^6 mg/kg)

BW = Body Weight (kg)
= 70 kg for an adult
= 16 kg for a child

APPENDIX I-- ACRONYMS & TERM DEFINITIONS

AEC	United States Atomic Energy Commission
ATSDR	Agency for Toxic Substances and Disease Registry
Background Level	The amount of a chemical that occurs naturally in a specific environment.
BEIR	The National Academy of Sciences Committee on the **Biological Effects of Ionizing Radiation.**
Cancer Classes	Each health organization has a separate method of cancer classification:

Environmental Protection Agency (EPA) (Based on 1986 cancer assessment guidelines):

A = Human Carcinogen.
B1 = Probable Human Carcinogen (based on limited human and sufficient animal studies).
B2 = Probable Human Carcinogen (based on inadequate human and sufficient animal studies).
C = Possible Human Carcinogen (no human studies and limited animal studies).
D = Unlikely to be a Human Carcinogen
E = Evidence of non-carcinogenicity in humans

Environmental Protection Agency (EPA) (Based on 2003 cancer assessment guidelines):

CA= Carcinogenic to humans
LI = Likely human carcinogen (cancer potential established; but limited human data)
SU = Suggestive evidence (human or animal data suggestive)
IN = Inadequate (data inadequate to assess)
NO= Robust data indicate no human carcinogen.

International Agency for Research on Cancer (IARC)

1 = Carcinogenic to Humans (sufficient human evidence).
2A = Probably Carcinogenic to Humans (limited human evidence; sufficient evidence in animals).
2B = Possibly Carcinogenic to Humans (limited human evidence; less than sufficient evidence in animals).
3 = Not Classifiable
4 = Probably Not Carcinogenic to Humans

National Toxicology Program (NTP)

1 = Known Human Carcinogen
2 = Reasonably anticipated to be a carcinogen
3 = Not Classified

CFR	Code of Federal Regulations
Completed Exposure Pathway	A way in which humans can be exposed to a contaminant associated with a site. An exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A completed exposure pathway has all of the 5 following elements: 1) A source of contamination 2) Transport through environmental medium 3) A point of exposure 4) A route of human exposure 5) An exposed population
COPD	Chronic Obstructive Pulmonary Disease
CREG	**Cancer Risk Evaluation Guides** are based on a contaminant concentration estimated to increase the cancer risk in a population by one individual in one million people over a lifetime exposure ($1x10^{-6}$).
CV	A **comparison value** is a calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process.
DHHS	United States Department of Health and Human Services
DOE	United States Department of Energy
EAA	Extrinsic Allergic Alveolitis
EDED	Emergency Department Encounter Database
EEP	Environmental Epidemiology Program at the Utah Department of Health
EMEG	**Environmental Media Evaluation Guides** are media-specific comparison values used to select contaminants of interest at hazardous waste sites. EMEGs are derived from Minimal Risk Levels (MRLs), developed by the Agency for Toxic Substances and Disease Registry (ATSDR), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e. children). MRLs are guidelines and are not used to predict adverse health effects. MRLs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.

EPA	The **U.S**. **Environmental Protection Agency** is the federal agency that develops and enforces environmental laws to protect the environmental and public health.
EPHTN	**Environmental Public Health Tracking Network** oversees the ongoing collection, integration, analysis, and interpretation of data about environmental hazards,exposure to environmental hazards, and health effects potentially related to exposure to environmental hazards
Exposure Dose	At some sites, the existing conditions may result in exposures that differ from those used to derive Comparison Values such as the EMEG. In these situations, the health assessor can calculate site-specific exposures more accurately using an exposure dose. The exposure dose can then be compared to the appropriate toxicity values (MRL, RfC, RfD).
HDD	Hospital Discharge Database
HOD	Health Outcome Data
Health-Based	see “Screening values”
HI	A **Hazard Index** is a sum of the hazard quotients for substances (in a given exposure) that affect the same organ or organ system.
HRSA	Health Resources and Services Administration
Hazard Quotient	The ratio of the potential exposure to the MRL or specific comparison value. A Hazard Quotient of less than 1 means that no adverse health effects are expected as a result of exposure. If the Hazard Quotient is greater than 1, then adverse health effects are possible.
IARC	The **International Agency for Research on Cancer**is part of the World Health Organization. The IARC studies and makes recommendations on the carcinogenicity of substances in terms of risks to human health.
ICP	Inductively Coupled Plasma
IHD	Ischemic Heart Disease
LOAEL	The **Lowest Observable Adverse Effect Level** is the lowest exposure level of a chemical that produces significant increases in frequency or severity of adverse effects.
LTSM	Long-term Surveillance and Maintenance

MCL	A **Maximum Contaminant Level** is an enforceable standard calculated by the United States Environmental Protection Agency. The MCL is the highest level of a contaminant that is allowed in drinking water.
MMTS	Monticello Mill Tailings Site
MRL	A **Minimal Risk Level** is defined as an estimate of daily human exposure to a chemical that is likely to be without an appreciable risk of deleterious non-cancer health effects over a specified duration of exposure. Thus, MRLs provide a measure of the toxicity of a chemical.
MVP	Monticello Vicinity Properties
NSDWS	**National Secondary Drinking Water Standards**or secondary standards are non-enforceable guidelines that regulate contaminants that may cause cosmetic or aesthetic effects in drinking water.
NIOSH	National Institute for Occupational Safety and Health
NOAEL	The **No Observable Adverse Effect Level** is the exposure level of chemical that produces no significant increases in frequency or severity of adverse effects. Effects may be produced at this dose, but they are not considered to be adverse.
NORM	Naturally Occurring Radioactive Materials
NPDWR	**National Primary Drinking Water Regulations** are legally enforceable standards that apply to public water systems. Primary standards are available on the web at: http://www.epa.gov/safewater/mcl.html
NPL	The National Priorities List is a list published by EPA ranking all the Superfund sites. Superfund is the common name for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a federal law enacted in 1980. This law was preauthorized in 1986 as the Superfund Amendments and Reauthorization Act. CERCLA enables EPA to respond to hazardous waste sites that threaten public health and the environment. A site must be added to the NPL site list before remediation can begin under Superfund.
NTP	The **National Toxicology Program** is part of the Department of Health and Human Services. NTP develops and carries out tests to predict whether a chemical will cause harm to humans.
OSHA	Occupational Safety and Health Administration

OU	Operable Unit
PEL	**Permissible Exposure Limit** for a hazardous substance or condition in the workplace as defined by the Occupational Safety and Health Administration (OSHA) General Industry Air Contaminants Standard (29 CFR 1910.1000).
PHA	**Public Health Assessment.**An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health.
PHAP	Public Health Action Plan
Potential Exposure Pathway	A possible way in which people can be exposed to a contaminant associated with a site. An Exposure pathway is a description of the way a chemical moves from a source to where people can come into contact with it. A potential exposure pathway has 4 of the 5 following elements: 1) a source of contamination 2) transport through environmental medium 3) a point of exposure 4) a route of human exposure 5) a receptor population
PPB	Parts per billion
PPM	Parts per million
PRB	A permeable reactive treatment wall, also referred to as a permeable reactive barrier, is a zoneof reactive material that is placed in a contaminated aquifer. As a result, concentrations of dissolvedinorganic contaminants are reduced as the groundwater passes through the material.
PRG	Preliminary Remediation Goals. Used for EPA Planning Purposes only.
Public Health Hazard	The category ATSDR assigns to sites that pose a health hazard to the public as the result of long-term exposures to hazardous substances. See "Public Health Hazard Categories".

Public Health HazardCategories	Categories defined by ATSDR and used in public health assessments that assess if people could be harmed by conditions present at a site in the past, present or future. One or more hazard categories may be assigned to a site. The five categories are: 1. Urgent Public Health Hazard 2. Public Health Hazard 3. Indeterminate Public Health Hazard 4. No Apparent Public Health Hazard 5. No Public Health Hazard
REL	**Recommended Exposure Limit** for a hazardous substance or condition in the workplace as defined by the National Institute for Occupational Safety and Health (NIOSH).
RESEP	Radiation Exposure Screening and Education Program
RfD	A **Reference Dose** is an EPA estimate, with uncertainty of safety factors built-in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.
RMEG	**Reference Dose Media Evaluation Guides** are media-specific comparison values used to select contaminants of interest at hazardous waste sites. RMEGs are derived from reference doses (RfDs), developed by the U.S. Environmental Protection Agency (EPA), and are an estimate of human exposure to a compound that is not expected to cause noncancerous health effects at that level for a specified period. They are intended to protect the most sensitive individuals (i.e. children). RfDs are guidelines and are not used to predict adverse health effects. RfDs do not take into account carcinogenic effects, chemical interactions, or multiple routes of exposure.
ROD	Record of Decision
Screening Values	Screening Values are health-based and media-specific concentrations that are used to select environmental contaminants for further evaluation in public health assessments. These values are not valid for other types of media, nor do concentrations above these values indicate that a health risk actually exists (agency that developed the value is in parenthesis for the examples below):

<u>Examples of Comparison Values for non-cancer health effects</u>

EMEG-c = Environmental Media Evaluation Guide for chronic (more than 365 days) exposure (ATSDR).

EMEG-i = Environmental Media Evaluation Guide for intermediate exposure (ATSDR).

EMEG-u = Environmental Media Evaluation Guides that are unpublished are designated with an asterisk by the authors of this health assessment and used only in the absence of published comparison values and are calculated using equations outlined in AppendixH.

RMEG = Reference Dose Media Evaluation Guide (ATSDR).

NPDWR = National Primary Drinking Water Regulations (EPA)accessed on web at: www.epa.gov/safewater/mcl.html

LTHA = Lifetime health advisory for drinking water (EPA).

Example of a Screening values for cancer health effects

CREG = Cancer Risk Evaluation Guide for $1x10^{-6}$ excess cancer risk (ATSDR).

SDWA	**The Safe Drinking Water Act**is the main federal law that ensures the quality of Americans' drinking water.SDWA was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply.
UCR	Utah Cancer Registry
UDEQ	Utah Department of Environmental Quality
UDOH	Utah Department of Health
µg/L	micrograms per liter
VMTE	Victims of Mill Tailings Exposure
WHO	World Health Organization
WL	Working Level
ZCTA	**Zip Code Tabulation Areas** are generalized area representations of U.S. Postal Service (USPS) ZIP Code service areas.
ZVI	Zero-valent ion

APPENDIX J-- COMMUNITY NEEDS ASSESSMENT

City of Monticello

The Utah Department of Health (UDOH) Office of Environmental Epidemiology (EEP) is currently conducting a Public Health Assessment on the Uranium Mill in the City of Monticello, Utah to evaluate exposures from past uranium milling that might affect public health under its cooperative agreement with the Agency for Toxic Substance and Disease Registry (ATSDR). As part of the process, the EEP staff has conducted various site visits and attended city council meetings. The goal of this needs assessment is to document and respond accordingly to the communities questions and concerns regarding the site.

Social Demographics

The City of Monticello, San Juan County, has a population of 1,958. The median age of residents is 29.6 years old, which is older than the median age of Utah, (27.1 years). The total population for San Juan County is 14,413. According to the 2005-2009 U.S. Census Bureau report, in San Juan County the median family income is $36,209. 22.6% of the families (875) in San Juan County fell below poverty level. The public education system consists of public schools (elementary, middle, intermediate and high schools). Of the residents in the City of Monticello, 87% are high school graduates or higher with 21% of the residents having earned a bachelor's degree or higher. In the City of Monticello 74.5% of the population are White, 0.8% are American Indian and Alaskan Native, 4.4% are Asian, 12.4% are Black or African American, and 7.0% are listed under other race, a compilation of all other races in Monticello. 15.1% of the population identifies itself as Hispanic or Latino (of any race). Nearly 79% of the homes are owner-occupied (Census, 2009).

Historical Data

The City of Monticello, Utah, is located in San Juan County in southeastern Utah is a city with a population of 2,212 (Census 2009). From 1943 through 1960 a uranium and vanadium processing mill operated immediately south of the City of Monticello. Due to chemical and radioactive contaminants from mill activities, the MMTS and affected surrounding properties were put on the National Priority List in 1986 and 1989 respectively. Remediation of contaminated soils from the MMTS and affected areas off of mill property was completed in 2000.

The Monticello Mill Tailings Site (MMTS) is a 110-acre abandoned uranium and vanadium processing mill in the City of Monticello. The Monticello Vicinity Properties (MVP) are off-site residential and commercial properties located within or near the City of Monticello. The United States Department of Energy (DOE) owned the site until 2000; at that time, remediation work on the site was completed and the City of Monticello was given the land through the National Park Service. The City of Monticello, private residents, and the state of Utah own various surrounding properties. No residences are located on the MMTS; however, residences are adjacent to the north and east edges of the MMTS.

The Vanadium Corporation of America opened a vanadium ore-buying station in the City of Monticello in late 1940 and began mill construction in 1941. In 1943, Vanadium Corporation began producing uranium-vanadium sludge for the Manhattan Engineer District. Construction of the Monticello plant, in addition to the mill proper, included the development of an adequate water supply, installation of a power plant, and construction of two large housing projects for workers. The staff town site, on the hill opposite the mill to the south, consisted of a staff house for 12 men, a manager's house, and 14 four-room family dwellings. The other housing project consisted of 32 two-room family houses and a bunkhouse and boardinghouse for 32 men. Intermediate owners and operators of the Monticello Mill Tailings Site included the War Assets Office; the Atomic Energy Commission (AEC); American Smelting and Refining Company; Galigher Company; Lucius Pitkin, Inc.; National Lead Company; the Bureau of Land Management; and the DOE. Mill operations were terminated on January 1, 1960. The ore-buying station remained open until March 1962. The mill tailings were stabilized by grading and covering with dirt and rock between 1961 and 1962, and the actual mill building was dismantled in 1964. Contaminated soils from the ore buying station were removed between 1974 and 1975. Milling processes used during the 11 years of AEC operation included raw ore carbonate leach, low-temperature roast/hot carbonate leach and salt roast/hot carbonate leach until 1955, acid leach resin-in-pulp and raw ore carbonate leach from 1955 to 1958, and a carbonate pressure leach resin-in-pulp process from 1958 until mill closure in 1960 (UNC Geotech, 1990).

Goal

Document and respond accordingly to the community's questions and concerns regarding the site.

Objectives

Provide Monticello community with the health assessment recommendations. Health education, in the form of informational packets pertaining to specific cancers of concern in the community, was made available to all residents in 2007. Following the release of the cancer cluster incidence study in December 2007, a public meeting was held in the community in June 2008 to discuss the results of the cancer study and to address community concerns. Packets were also made available to residents at the public meeting and additional copies were released to the Southeastern Utah Public Health Department (SEUHD) for health education purposes. Additional educational activities are proposed for the community of Monticello (workshops, health fairs, public school programs); these will be managed and overseen by the SEUHD.

Community Concerns

The Victims of Mill Tailings Exposure (VMTE) is a group of concerned citizens, pursuing information regarding the Monticello mill site and the exposure that the local residents experienced when the uranium mill was operational. Many residents have moved but lived in or near the City of Monticello during the operation of the mill and before final clean up.

The VMTE needs assessment tool was sent to current and past residents of the City of Monticello, Utah. Of the needs assessments that were mailed out, 194 were completed and returned to the VMTE. According to the needs assessment tool the residents expressed a number of concerns. The major impact the community as a whole believes they faced between 1940 and 1960 was blowing dust and dirt (55%). Of residents surveyed, time of residence ranges from 1 to 82 years. The responding residents fall within 28-88 years of age. According to the VMTE survey, 1993, 39% of surveyed residents worked at the mill for an average of 5.5 years (ranging from 1-21 years). Of the surveyed residents 81 (42%) have been diagnosed with cancer; such cancers include but are not limited to; lung (9), breast (8), lymphoma (7), skin (40), leukemia (2), and prostate (10). Although a higher number of cancers would be expected due to the difference in elevation between Monticello (at approximately 7,000 feet) and a city near sea level, resulting in Monticello residents receiving a higher exposure to UV radiation, the number of cancers observed in this small population of 1800 people cannot solely be an artifact of the elevation difference.

Twenty five percent of surveyed residents feel that respiratory problems are occurring with abnormal frequencies within their families, with 24% who consider allergies the greatest concern. When asked to identify the biggest impact the uranium mill has placed on residents and or their families, 14% responded loss of income, 5% indicated home repairs due to metal corrosions and other deterioration, 2% responded to a total loss of their home, 3% had excessive auto repairs and 20% listed medical expenses.

The following comments are those of the residents in the City of Monticello that responded to surveys completed by the VMTE in 1993 and updated in 2006, as many of the same community concerns, behaviors and beliefs still existed. The comments are divided into the following categories: concerns, knowledge, attitudes/beliefs, and practices/behaviors:

Concerns:

- Our garden would never grow anything.
- Window screens and cloths lines turned red.
- Mill area was not fenced in.
- We sent a letter to Grand Junction in 1967 identifying our problems. They didn't acknowledge the letter.
- Acid caused holes in clothes, acid ate chrome off cars, acid turned fences rust colored.
- Many people had bad teeth at an early age.
- My entire family has or is suffering from cancer.
- Kids swam in the polluted water, stock water.
- We had no protection from the uranium filtering press.
- The house was always filled with mill dust.
- Entire family has respiratory problems.
- Injuries (scrapes) took a long time to heal.
- Eye deformities.
- Especially noticed odor at 100 east Highway.
- Stomach aches.
- Daily headaches.
- Loss of feeling in arms and legs and loss of coordination.
- My family has suffered many diseases, various cancers, lung disease, chronic headaches, and chronic coughs.
- Work clothes were laundered with the family wash.
- Medical expenses.
- Due to illnesses we are unable to get medical insurance coverage.

- Dose from radiological isotopes that community residents were exposed to throughout the operation of the facility and following the closure of the facility.

Knowledge:

- Always dirt blowing from the mill site.
- I remember numerous times mom saying about how when the wind would blow, her sheets on the clothes line would become yellow and brittle.
- We had a lot of nose bleeds and sore throats.
- Autos and other metals seemed to corrode faster than normal.
- Yellow covering on everything.
- Doctors can't explain cause of many health conditions.
- When the wind blew from the north the mill dust would burn my eyes and lungs.
- The screens would disintegrate off from the windows.
- The chains on our swings turned green.
- My dad put in complaints a number of times about tailings getting into the creek- we irrigated and it killed crops as well as animals.
- I remember announcements to remain indoors during the Nevada tests and looking out the window at the unusual cloud formations above.

Attitude/Beliefs:

- I fully believe that it was a very unhealthy environment, but I seemed to have come out ok.
- We thought the tailing piles were sand hills.
- I believe my wife contracted cancer because I worked in the mill.
- Sulfur smoke was excessive.
- As a rule our air is pretty good.

Practices/Behaviors:

- Played on tailings as a kid, played with balls from mill.
- We had to replace screen windows and door wires yearly.
- I worked in yellow cake- my skin turned yellow.
- On windy days our windows had to be shut because there was ore dust all over.
- In the 50's the mill was fenced and gates locked after hours and during off times. Signs were posted to keep out.
- The mill was our family's sole income source.

Educational Diagnosis

Actions have been taken to improve the overall health and well being of the community, such as:

- In 1980, the Monticello Remedial Action Project was established to remove chemical and radiological hazards from the MMTS and surrounding properties.
- In 1983, separate remediation projects for the Monticello Mill Tailings Site (MMTS) and the Monticello Vicinity Properties (MVP) were established. The DOE has primary responsibility for remediation activities at both sites.

- The MMTS and the MVP were added to the National Priority List in 1989 and 1986 respectively.
- The MMTS was divided into three distinct operable units (OU):
  - Operable Unit I Mill Site Tailings and Mill Site Property
  - Operable Unit II Peripheral Properties
  - Operable Unit III Surface Water, Groundwater and Contaminated Sediments in Montezuma Creek Canyon
- Remediation activities were completed for OU I and OU II in 2001.
- A total of 30 peripheral properties, non-mill owned properties that were adjacent to the site, were remediated. Remediation of OU III was completed in 2004.
- Throughout the operating period of the mill, tailings from the MMTS were windblown into the City of Monticello and were intentionally used in various construction activities in the city. Remediation of the MVP began in 1984 and was completed in 1998. A total of 424 properties were remediated to remove tailings from soil, concrete, brick mortar, plaster and other contaminated construction materials. All contaminated materials were placed in a permanent repository south of the MMTS.

Implementation

Members of the community feel their health is in jeopardy due to the numerous chemicals and radioactive contaminates produced by the uranium mill. UDOH conducted a cancer incidence study in the City of Monticello in 2007. Currently the UDOH EEP is conducting a public health assessment to determine if there are health risks from the uranium mill, the results will be distributed to the residents upon completion.

The health educator will continue to monitor the reports and research of the findings in the City of Monticello and will conduct health education as recommendations are concluded from the public health assessment or as needed. The health educator will work with the local Health Department and City officials to ensure the messages and materials are appropriate for the community.

Upon completion of the investigation, a fact sheet will be developed and distributed to the residents in the City of Monticello and surrounding areas. The fact sheet will address resident concerns; contain information about the environmental testing/sampling process along with the results, and an outlook for the future. Information on how residents can obtain a complete copy of the public health assessment will be provided. The residents will be informed of all ongoing activities surrounding the site.