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MISCELLANEOUS RADIOACTIVE MATERIALS DETECTED DURING URANIUM MILL TAILINGS SURVEYS

Mary J. Wilson

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MISCELLANEOUS RADIOACTIVE MATERIALS DETECTED DURING URANIUM MILL TAILINGS SURVEYS

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Date Published: October 1993

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

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ACKNOWLEDGEMENTS

I wish to acknowledge and thank the technical personnel and management of the Pollutant Assessments Group for their contributions and continuing support of the Monticello activities. In particular, recognition goes to D. B. Ertel and G. K. Stowe for field-team leadership; A. R. Jones, S. M. Fields, and S. K. Mather for technical/field support; D. S. List, M. E. Mumby, D. L. Sellers and S. M. Smith for the coal investigation; G. A. Pierce for radionuclide analysis, N. F. Lewis for computer programming, C. D. Retolaza and E. P. Schlauger for public relations and data base support; J. W. Crutcher and B. J. Krall for technical writing/editing; and D. K. Halford and Craig A. Little for PAG management. D. N. Mackenzie, W. E. Murphie, and D. J. Williamson, in support of the Department of Energy, were valuable sources of direction and encouragement throughout the study.

ABSTRACT

The Department of Energy's (DOE) Office of Environmental Restoration and Waste Management directed the Oak Ridge National Laboratory Pollutant Assessments Group in the conduct of radiological surveys on properties in Monticello, Utah, associated with the Monticello millsite National Priority List site.

During these surveys, various radioactive materials were detected that were unrelated to the Monticello millsite. The existence and descriptions of these materials were recorded in survey reports and are condensed in this report. The radioactive materials detected are either naturally occurring radioactive material, such as rock and mineral collections, uranium ore, and radioactive coal or man-made radioactive material consisting of tailings from other millsites, mining equipment, radium dials, mill building scraps, building materials, such as brick and cinderblock, and other miscellaneous sources.

Awareness of the miscellaneous and naturally occurring material is essential to allow DOE to forecast the additional costs and schedule changes associated with remediation activities. Also, material that may pose a health hazard to the public should be revealed to other regulatory agencies for consideration.

1. INTRODUCTION

In 1978, under the authority of the Atomic Energy Act, the U.S. Department of Energy (DOE) established the Surplus Facilities Management Program (SFMP) to manage the maintenance and surveillance of numerous DOE-owned, radioactively contaminated facilities that were declared surplus and to conduct a program leading to the ultimate disposition of those facilities. The former uranium millsite at Monticello, Utah, is one such facility and is the focus of the Monticello Remedial Action Project (MRAP). Properties surrounding the millsite and contaminated with millsite material are also subject to cleanup under SFMP. These are addressed in the Monticello vicinity properties (MVP) project. The general location of Monticello, Utah, and detail of the Monticello area are shown in Figs. 1 and 2.

The primary responsibility of SFMP, now referred to as the Office of Environmental Restoration and Waste Management (EM), was to protect public health and the environment from potentially harmful radioactive material contained within or derived from DOE-owned facilities. Management of MRAP and MVP is currently directed within EM by the Division of Southwestern Area Programs at DOE Headquarters, Washington, D.C. The Superfund Amendment and Reauthorization Act of 1986 (SARA) placed the SFMP-MVP activities under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Environmental Protection Agency (EPA), DOE, and the state of Utah entered into a federal facilities agreement (FFA) in December 1988 to complete remedial action at both MRAP and MVP. The FFA details the responsibilities of all parties and the scope of the project. The reader is thus referred to the FFA work plan for a further description of project scope, regulations, and responsibilities (UNC Geotech 1989a).

Prior to the remediation of the Monticello millsite under MRAP, privately owned properties surrounding the millsite were assessed for inclusion in the MVP

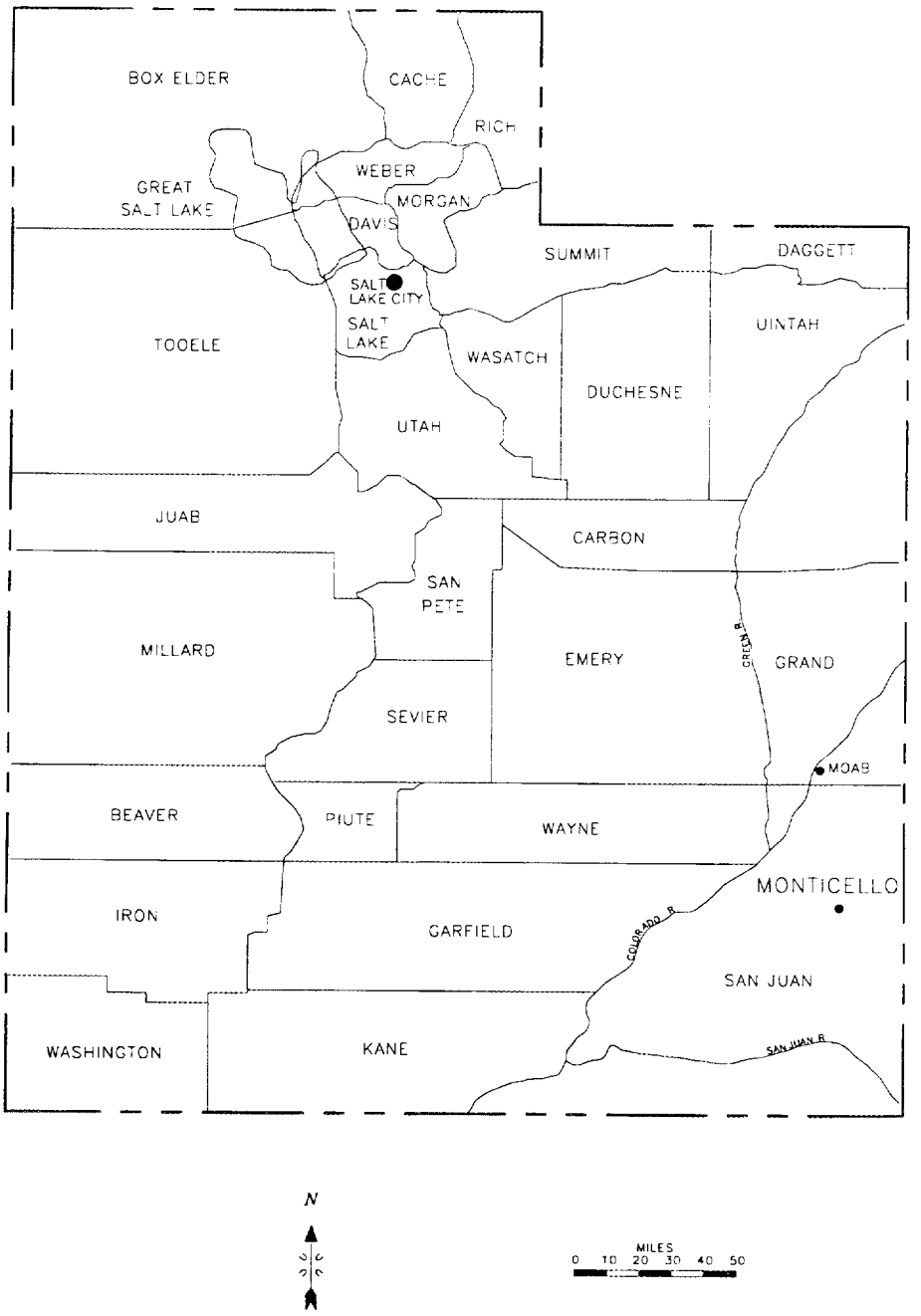

Fig. 1. Monticello, Utah, in San Juan County.

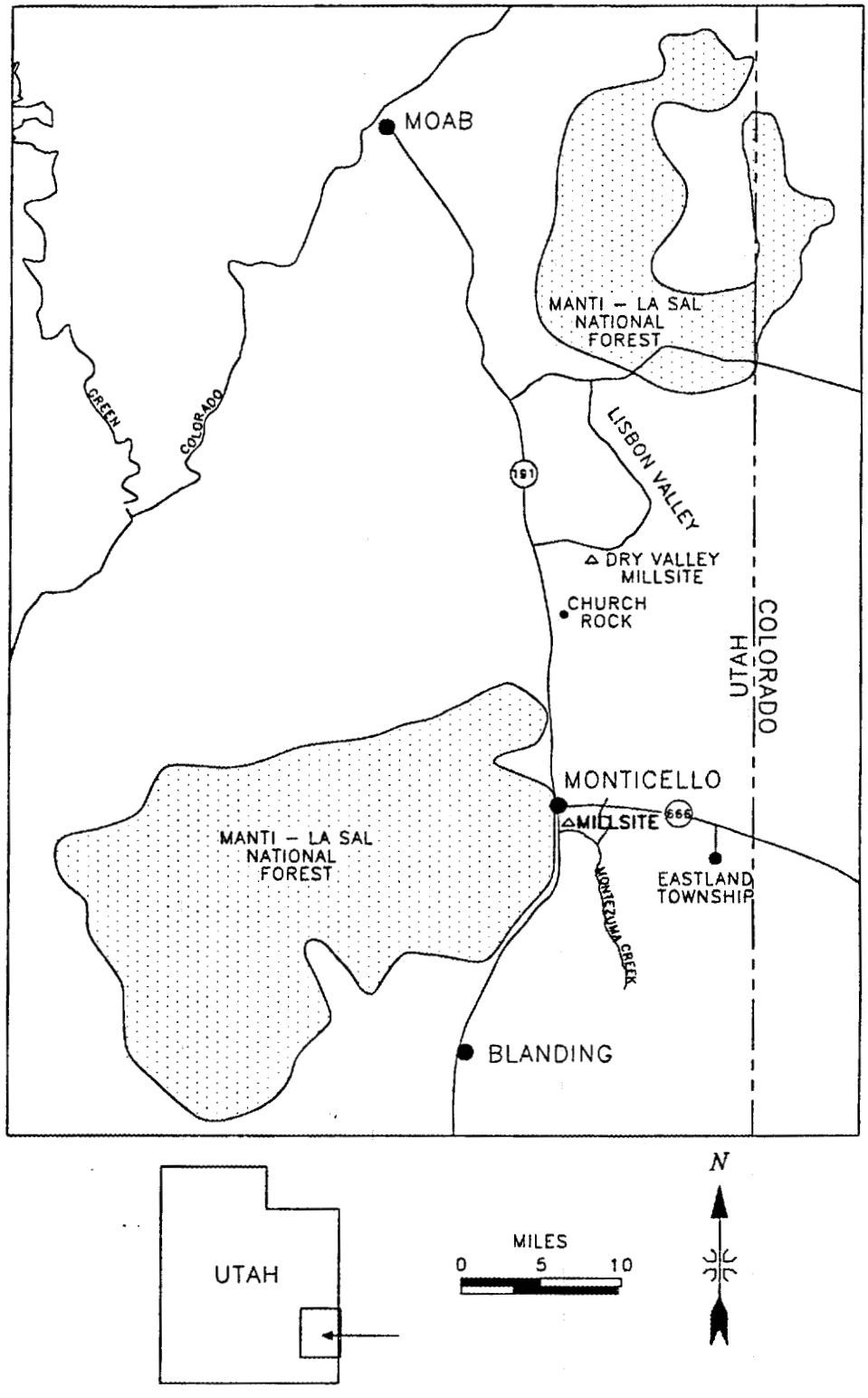

Fig. 2. Detail of San Juan County.

project. The Pollutant Assessments Group (PAG) of Oak Ridge National Laboratory (ORNL), Grand Junction, Colo. (GJ), was directed by DOE in July 1988 to conduct surveys of the radiological condition of properties potentially contaminated with Monticello mill-related materials. Those with associated radiation levels that exceed DOE guidelines and the EPA standards set forth in 40 CFR 192 are eligible for cleanup under the MVP project (U.S.DOE 1987; U.S.EPA 1991). ORNL/PAG performed 786 gamma radiation screening surveys for mill-related materials.

2. OBJECTIVE

The objective of this report is to describe and document the various radioactive materials unrelated to the Monticello millsite that were detected during MVP radiological screening surveys. The existence of these materials was recorded in survey reports throughout the MVP inclusion survey process. The radioactive materials detected during surveys are either naturally occurring or anthropogenic (i.e., caused by man). Naturally occurring radioactive material (NORM) consists of rock and mineral collectors' items, uranium ore, and radioactive coal. Anthropogenic material consists of Dry Valley mill tailings, mining equipment, radium dials, mill building scraps, building materials such as brick and cinderblock, and other miscellaneous sources.

Radioactive materials unrelated to the Monticello millsite may present a possible health risk to the public if used as fill material beneath structures or as masonry constituents. These materials can produce elevated ^{226}Ra concentrations in soil that result in elevated radon progeny. Naturally occurring radioactive materials present in geological formations in the western states may pose the same health-risk potential as mill-related radioactive material if used outdoors or as fill material beneath structures. However, since no known Monticello structure sits directly on any such formations, *in situ* hazards are not considered here.

On the other hand, non-Monticello mill-related material can be excavated as if it were residual material from the Monticello millsite. The cost of such clean-ups will be at the expense of DOE, according to an agreement between DOE, EPA, and the state of Utah, even though some of the material may be unrelated to DOE activities at the previously operated Monticello millsite.

3. BACKGROUND

3.1 HISTORY OF RADIOACTIVE MATERIALS

Commercial mining of uranium-bearing carnotite and tyuyamunite ores began in Colorado and Utah in the early decades of the 1900s. Processing mills were constructed near large mines or an artery of small mines to stockpile, grind, and leach the ore for radium (used as luminous paint and in medical radiography) and vanadium (used for hardening steel). These privately owned mines and mills were operated until the ore source was exhausted, which could have been for a few months or a few years. Once the mines became unprofitable, they were abandoned, as were the mills they supplied.

During World War II, the demand for vanadium increased, and ores that previously would have been unprofitable were mined and processed for their vanadium content. Additionally, the war effort and its defense-related projects for the development of nuclear energy provided an increased demand for uranium and plutonium, a synthetic element produced from uranium. The Army Corps of Engineers' Manhattan Engineer District, established in 1942 to develop nuclear energy, relied on three sources for uranium: 1) the Belgian Congo, which supplied about two-thirds; 2) the Great Bear Lake mines of Canada, which supplied about one-sixth; and 3) the United States, which supplied the remainder.

Most domestic uranium was supplied by the carnotite ores of the Colorado Plateau. However, the high-grade uranium deposits had been exhausted by the demand for radium. Thus, this domestic supply of uranium consisted primarily of uranium oxide obtained from tailings resulting from vanadium refinery operations (UNC Geotech 1989b).

The radioactive mill tailings that are by-products of the uranium and vanadium milling processes are stored in piles near the mills. If not contained and controlled, these sandy materials can be scattered about the environment by erosion and human intervention. Radiological surveys conducted at the request of DOE have determined that local area residents near a tailings storage site sometimes remove these radioactive materials for use as fill or as aggregate in concrete or mortar. When the origin of these materials can be traced to a government-owned or formerly government-owned facility, it is the policy of DOE to remove any radioactive material that may be present on privately owned vicinity properties. As a result of radiological surveys conducted as part of the MVP project, properties with radioactive material that resulted from sources other than the government-owned millsite have been identified. This report will concentrate on the origin and description of these radioactive materials and identify some of the parameters that may be used to determine if the source is the DOE-owned Monticello mill or some other source, such as the Dry Valley millsite or naturally occurring geological formations.

3.2 MILLSITES

The millsite at Monticello, Utah, was built in 1942 by the United States government to provide vanadium during World War II. Various government agencies operated the mill until 1947. In 1948, the Atomic Energy Commission (AEC) obtained the mill and operated it under contract through 1959 for the

purpose of producing both uranium and vanadium. During the AEC era, the mill processed approximately one million metric tons of uranium ore. Because uranium and vanadium were the only substances extracted in the milling process, other constituents of the ore such as radium and thorium remained in the tailings at the time of their disposal. Throughout the mill's operation, area residents used these tailings as fill material and as aggregate in mortar and concrete. On January 1, 1960, mill operations were terminated, and in July 1965, the ore stockpiles and other contaminated material were removed from public access and the millsite foundations covered with topsoil. During 1974 and 1975, additional cleanup by DOE included demolition of the concrete foundations and their subsequent trench burial. In 1981, the millsite was declared surplus and accepted into the SFMP; it awaits remedial action to bring its condition up to current DOE standards.

Another millsite in the area is a privately owned, former vanadium mill, the Dry Valley millsite, located approximately 40 km northeast of Monticello (Fig. 2). This mill produced vanadium from 1931 to 1938. Monticello residents and building contractors used radioactive material from this site extensively. The Dry Valley millsite was covered and revegetated in 1984.

3.3 PREVIOUS SURVEYS

Several radiological investigations and surveys were conducted in Monticello prior to the assignment of ORNL/PAG in July 1988 as the primary survey contractor. In 1971, EPA sponsored a survey that investigated 494 structures in Monticello and recorded 62 radiological anomalies. In 1980, another EPA-sponsored survey examined 810 structures and recorded 55 gamma radiation anomalies (gamma radiation measurements 20% greater than background) (U.S.EPA 1984). These EPA surveys, using mobile gamma detection, were performed at the request of property owners. In 1982, Bendix Field Engineering Corporation surveyed

the properties identified by the EPA surveys to provide further information on their radiological condition. In 1983, ORNL, Oak Ridge, Tenn., conducted a mobile gamma scan that located 36 additional properties exhibiting anomalous gamma levels (Little and Berven 1985). On-site surveys were conducted at these properties and at the previously identified properties to once again assess radioactive material for inclusion in the remedial action program.

In addition to investigations and surveys conducted by EPA and DOE, other radiological studies were performed in Monticello in the early 1980s. A legal action alleging that seven leukemia deaths in Monticello were the result of ionizing radiation emanating from the Monticello mill tailings piles prompted studies by the University of Utah and others. These studies involved the measurement of cumulative gamma radiation dose from brick and porcelain samples obtained from residences throughout the town (Johnson 1990).

In light of this history, MRAP and the MVP project, in accordance with SARA, were placed under the regulatory framework of CERCLA. Both the MRAP and Monticello millsite MVP have been on the National Priorities List (NPL) since 1987. Because MVP are on the NPL, extra measures to identify potentially contaminated properties were undertaken. In 1989, DOE directed UNC Geotech and ORNL, both in Grand Junction, Colo., to survey all privately owned properties within a six-section area encompassing the city of Monticello and surrounding populated properties. There are approximately 1,000 MVP; these are outlined in Fig. 3.

3.4 SURVEY PROCEDURE

Consents to access properties were obtained from landowners, radiological screening surveys were performed, and soil samples were collected and analyzed for each vicinity property.

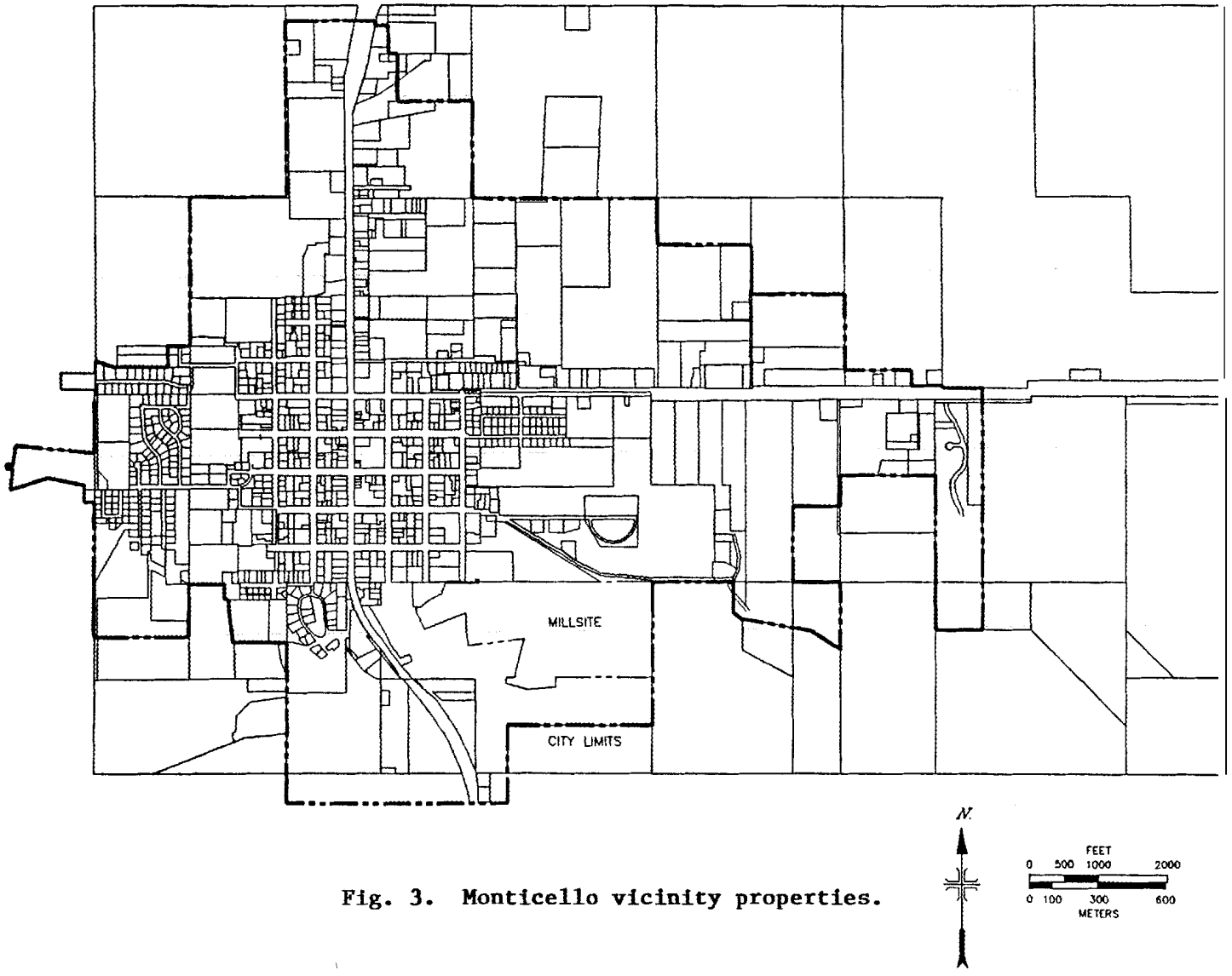

Fig. 3. Monticello vicinity properties.

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Radiological surveys were in accordance with DOE-approved radiological survey procedures developed by ORNL/PAG for use in the MVP project and also in the Uranium Mill Tailings Remedial Action Project (UMTRAP)(ORNL 1990). These surveys covered each land parcel in its entirety. Radiation exposure rates were recorded and mapped. Soil samples were collected at each property from locations exhibiting elevated gamma levels or from locations exhibiting general background if no elevated gamma exposure rates were detected. The soil samples were then laboratory-analyzed for ^{226}Ra, ^{40}K, and ^{232}Th using a NaI gamma spectrometer. It should be noted that background gamma ranges from 11 to 15 μR/h with an average value of 13 μR/h (Little and Berven 1985).

3.5 SURVEY RESULTS

ORNL has surveyed 786 MVP since 1988, of which 215 exceeded DOE guidelines, 512 did not exceed, and 59 are currently in the radon daughter concentration (RDC) monitoring process.

Elevated radiation levels that included non-Monticello mill-related radioactive material were noted during surveys. When possible, the existence of non-Monticello mill-related radioactive material was documented in the survey by a statement from the property owner, and these properties were not included for remedial action in the MVP project. However, in some instances documentation of radioactive material origin was not possible, or the radioactive material was a combination of sources related and not related to the Monticello millsite. When these cases were encountered, it was the policy of DOE to take the conservative approach of including these properties for remedial action if they exceeded DOE guidelines. Radioactive materials that did not result from Monticello millsite activities include: 1) radioactive material originating from the Dry Valley millsite, 2) material from various uranium mines, 3) ore samples acquired by area residents as "collectors' items", 4) radioactive coal used by residents for heat and for fill material, and 5) other miscellaneous sources. These materials are described in the following pages.

4. DRY VALLEY MILLSITE

4.1 HISTORICAL BACKGROUND

Dry Valley, Utah, is the large expanse of land between the La Sal Mountains near Moab, Utah, and the northern end of the Abajo (Blue) Mountains west of Monticello. The Dry Valley millsite is located east of Highway 191, in Lisbon Valley off local Highway 46, approximately 40 km north of Monticello, in Township 30 South, Range 24 East Sect. 35 (USGS 1987) (Figs. 4 and 5). Most of Sect. 35 is owned by the federal government; however, in the eastern half of the northwest quarter of Sect. 35 are two 0.16-km^2 parcels of privately owned land. The Dry Valley millsite is located on this privately owned land.

San Juan County Court House records list the International Vanadium Corporation as the earliest owner of these two parcels of land. In 1933, ownership was transferred to the Molybdenum Corporation of America (Moly Corp), the current owner of record. Moly Corp was acquired by Unocal in July 1977 and is operated as a wholly owned subsidiary.

Earlier ownership of the Dry Valley millsite and the exact period of mill operation are uncertain. A local history (Perkins et al. 1968) states that the old United States Vanadium Company built a 20-ton (1.8×10^4 kg) mill 35 km northeast of Monticello in 1924 and the Alloy Corporation built a mill in Dry Valley in 1929. Another source (Minobras 1978) denotes the Dry Valley mill in its Colorado/Utah listing and states that the Dry Valley mill produced vanadium during the years 1931 to 1938. Regardless of the exact period of operation, when the ore supply was exhausted, the millsite was abandoned.

There has been no activity in the area since 1977 when the land was obtained by Moly Corp other than reclamation of the Dry Valley millsite in 1984. In February or March 1984, Unocal was requested by the state of Utah, Bureau of

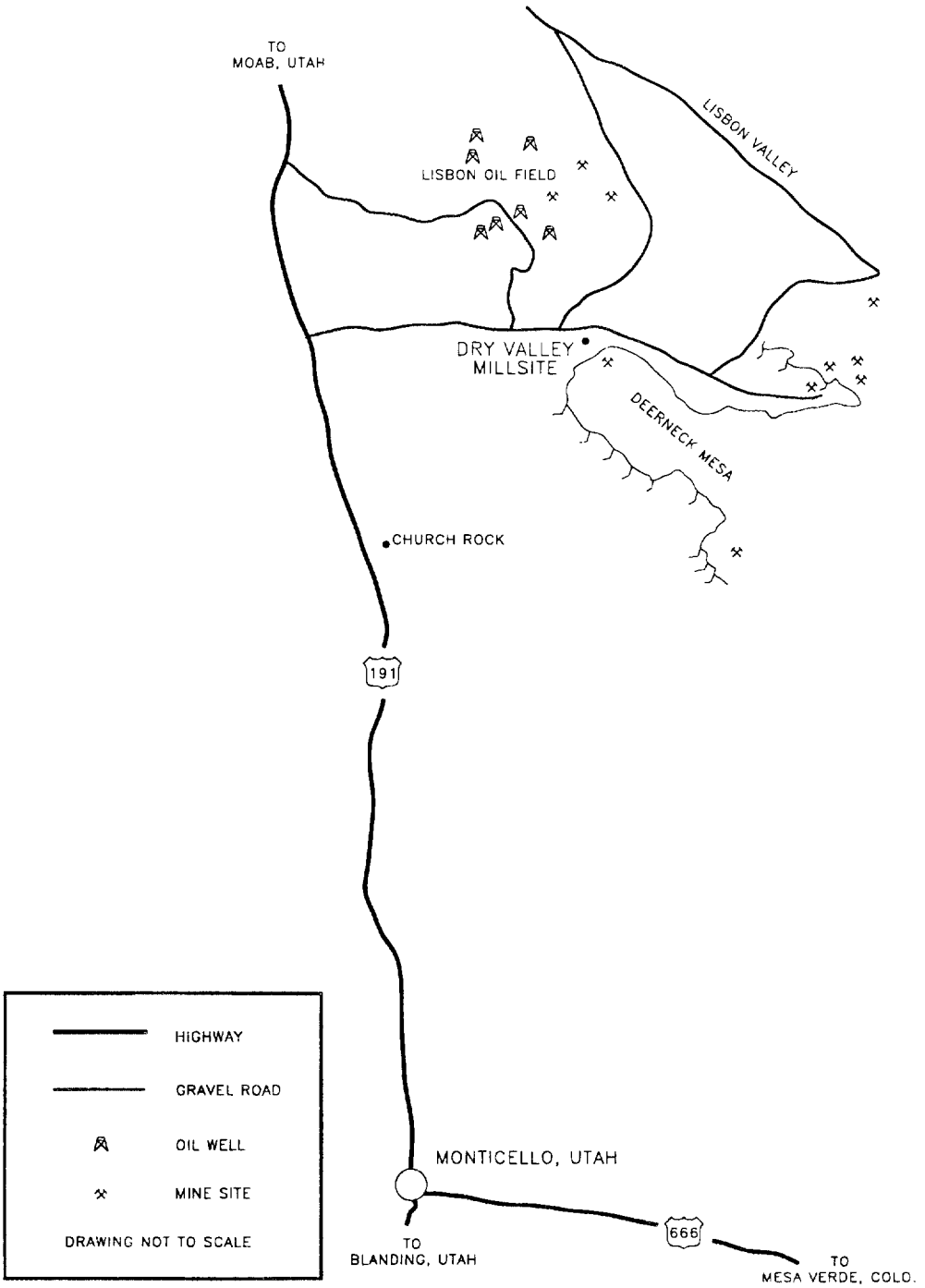

Fig. 4. General location of the Dry Valley millsite.

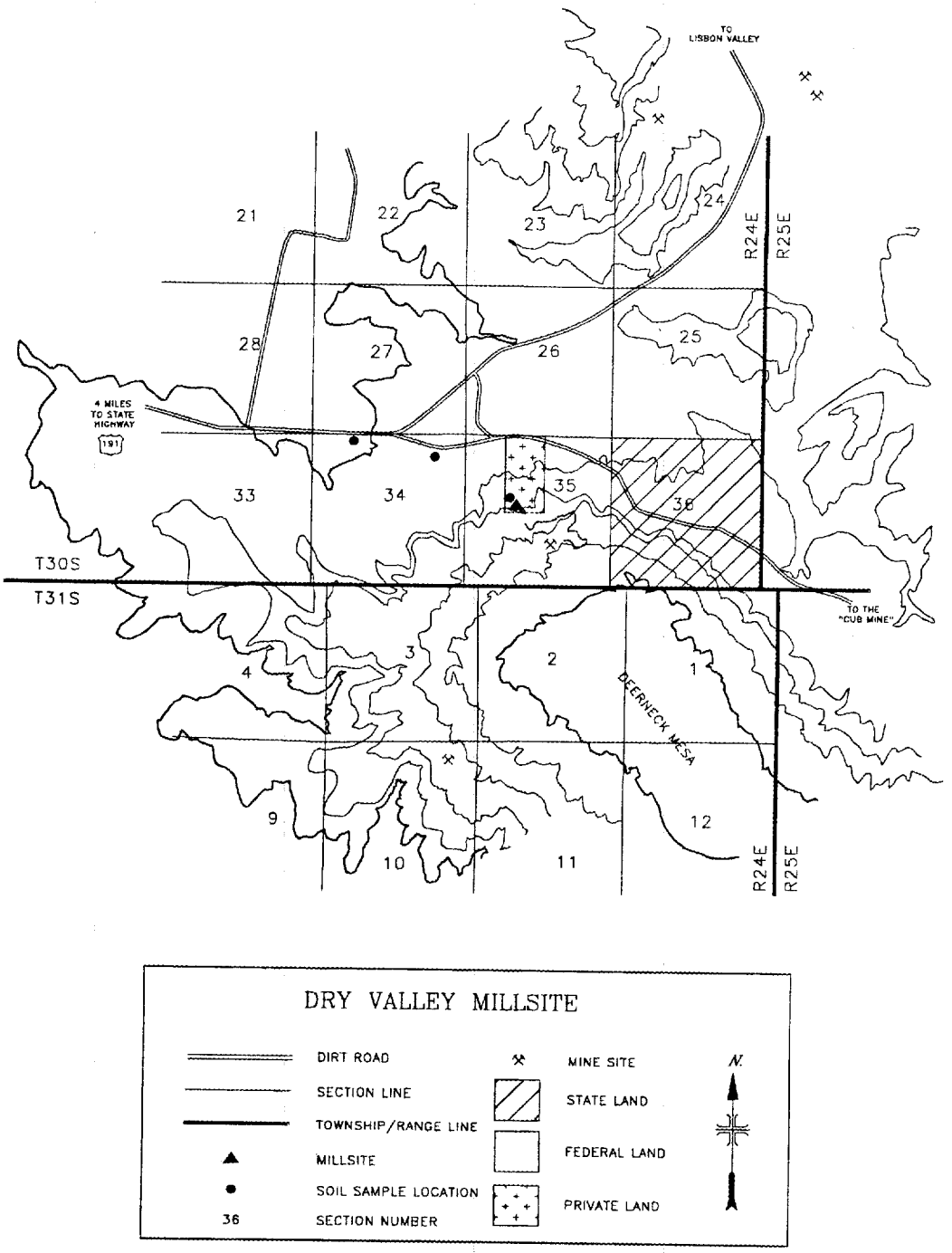

Fig. 5. Detailed location of the Dry Valley millsite.

Radiation Control, to remove Dry Valley millsite tailings from public access. The state of Utah indicated that up to 100 buildings in Monticello were contaminated from use of Dry Valley tailings material. Unocal and the state of Utah discussed possible options for remediating the site. The options were to: 1) remove the tailings from the millsite, place them in an abandoned mine, and seal the entrance; 2) fence the area; or 3) stabilize and cover the tailings with appropriate material. Unocal studied the options and proposed a reclamation plan that involved grading the tailings, covering with 1 m of local top soil, and revegetating with local plants (personal communication with G. R. Morris, Union Oil Co., Parachute, Colo., June 1990). The plan was approved by the state of Utah, and reclamation was completed in June/July 1984. The state of Utah indicated acceptance of the work performed (Anderson 1984).

4.2 PHYSICAL DESCRIPTION

Surrounding the Dry Valley millsite is land owned by the U.S. Bureau of Land Management and used primarily for cattle grazing. The old mill sits directly on an outcrop of the Entrada Formation. This outcrop, commonly called the slickrock, forms a flat, sandstone surface below the mill that was apparently used to stockpile ore for mill processing. Remnants of carnotite and other ore remain and can be detected by their yellowish color or by elevated readings on a gamma scintillometer.

All that remains of the mill is its concrete foundation, timbers, and a few scraps of metal and steel reinforcing bar. Above the mill, where ore was once stored, are scattered piles of carnotite. Below the mill, stretching out in the general shape of a tongue, is the tailings pile, extending over 91 m. The tailings pile is covered with approximately 1 m of dirt and sparse vegetation. However, tailings materials are eroding from beneath the cover, and tailings are exposed near the mill. Water erosion has carried tailings toward a wash that runs along the side of and below the road.

4.3 RADIOLOGICAL PROFILE

In June 1990, surface gamma radiation measurements were taken over part of the Dry Valley millsite by ORNL/PAG. Readings were taken with a gamma scintillometer in thousand counts per minute (kcpm) and converted to exposure rate (μR/h) using the conversion factor derived for the Monticello, Utah, area: μR/h = 1.46 kcpm + 7.2. Scintillometer readings were converted to exposure rates so that gamma measurements at the Dry Valley millsite could be compared to background gamma radiation exposure rates for the Monticello area. As part of the MVP project, Monticello background radiation had been investigated by ORNL/PAG. The range of gamma radiation exposure rates measured at background locations in Monticello was 13 to 16 μR/h; the average exposure rate was 14 μR/h.

Pieces of yellowish uranium ore at the perimeters of the Dry Valley tailings pile have gamma radiation exposure rates on contact of approximately 36 μR/h. Exposure rates measured over the dirt cover that shields the tailings pile ranged from 29 to 44 μR/h. Where tailings had eroded from the cover, measurements roughly doubled, ranging from 66 to 80 μR/h. Emanation from the tailings pile could be detected for a distance of about 61 m, and gamma radiation exposure rates increased with proximity to the mill. Exposure rates exceeded 150 μR/h both around the pillars of the millsite and above the mill. Near the ore piles, exposure rates exceeded 300 μR/h.

Two soil samples were taken from the mill tailings pile and analyzed for ^{226}Ra concentrations. Results of this analysis revealed ^{226}Ra concentrations of 200 pCi/g and 67 pCi/g. A sample was also collected from the sand wash 46 m below the pile. Analysis yielded a ^{226}Ra concentration of 6 pCi/g. Since background level for the area is 2 pCi/g (Rust Geotech 1993), this may indicate that water has eroded material from the pile and dispersed it throughout the wash below. Table 1 lists ^{226}Ra concentrations for samples taken from the Dry Valley millsite and vicinity.

Table 1. ^{226}Ra concentrations of material collected at the Dry Valley millsite

Sample number	^{226}Ra Concentration, pCi/g	Sample Depth, cm	Location
S1	302	0 to 15	White sand near former loading area
S2	94	0 to 15	White sand on small bench above millsite
S3	5.7	0 to 15	46 m below pile in wash
S4A	8.2	0 to 15	~0.8 km west of pile along dirt road
S4B	7.2	15 to 30	~0.8 km west of pile along dirt road
S5	8.8		
S6	1.4	0 to 15	~1.6 km west of pile along dirt road

Despite these elevated radiation measurements, the Dry Valley millsite was readily accessible to the public as late as June 1990. No radioactive warning signs were posted. The mill site and adjoining tailings pile were not fenced. There was no warning or boundary to deter the local populace from driving up to the mill tailings site and taking sand for use in masonry on concrete structures or as fill in yards, driveways, and children's sandboxes.

Gamma measurements taken over parts of the Dry Valley millsite were all above the background level of 13 to 16 μR/h for the Monticello area. Because the Dry Valley millsite is privately owned and was never used in support of government activities, it is not subject to the DOE guidelines for residual radioactive material at the Formerly Utilized Sites Remedial Action Program (FUSRAP) and SFMP sites (U.S.DOE 1987). Guidelines for control of tailings piles and cleanup of buildings and land are found in 40 CFR Part 192 (U.S. EPA 1991). For control of tailings piles, these guidelines are based on radon emissions from the surface of tailings pile (no more than 20 pCi/m^2). For buildings, the guidelines are based on: (1) radon (an annual average not to exceed 0.02 working levels [WL] and a maximum limit of 0.03 WL) and (2) gamma exposure rates (a maximum measurement of 20 μR/h). For land, the guidelines are based on concentrations of ^{226}Ra in soil: a maximum of 5 pCi/g in surface soil, 0 to 15 cm (0 to 6 in.) deep and 15 pCi/g in subsurface soil, >15 cm (>6 in.) deep. Since the Dry Valley millsite was a vanadium mill before the Manhattan Project era, the 40 CFR 192 standards may not apply because they address by-products of uranium millsites.

4.4 USE OF DRY VALLEY TAILINGS ON MVP

In October 1989, DOE directed ORNL to research the use of Dry Valley millsite material by local Monticello building contractors. Property owners whose buildings were found to have elevated gamma radiation rates were questioned

during radiological surveys about the possible origin of construction materials. The owners consistently reported that the structures in question were built by one specific local masonry contractor. The structures were usually brickwork, such as brick siding, fireplaces, chimneys, and occasionally rock masonry. The primary contractor reported to have used the material was contacted and interviewed during June 1990. ORNL was supplied with verbal confirmation of the following points:

- The masonry contractor's company was formed in 1973, after the Monticello millsite tailings pile was stabilized. Material from the Monticello millsite was never used in the contractor's projects.

- The sand used by the masonry contractor in mortar for brick masonry came from all over southeastern Utah, and was not limited to one source. Sand was hauled from the Dry Valley millsite in addition to dry washes in the Lisbon Valley and Church Rock areas. Sand was also purchased in Cortez, Colo., and in Dolores, Colo. The sand from these distributors came from various sources, including Shiprock, New Mexico, and Mexican Hat, Utah.

- The masonry contractor provided a written statement that Monticello millsite material was never used in his construction projects. The contractor compiled a list of locations of masonry structures (Appendix A). When the list was received, it was checked against surveys of properties containing radioactive brick masonry structures (personal communication with Bunker Construction, June 1990). Approximately 35% of the properties on the contractor's list were also properties where surveys had detected radioactive masonry. Thus, it was determined that the material found on the surveys was not from the Monticello millsite but was probably from the Dry Valley millsite (Appendix A and B).

In addition to the Dry Valley tailings used by contractors, several property owners reported using Dry Valley tailings for brick mortar, concrete matrix, sandboxes, and fill.

4.5 RADIATION LEVELS ON MVP FROM DRY VALLEY MATERIAL

The outdoor gamma radiation exposure ranges on properties containing Dry Valley mill tailings vary from a low of 17 to a high of 80 μR/h. Indoor exposure ranges vary from a low of 16 μR/h to a high of 92 μR/h. Radon progeny have been measured inside homes with masonry structures (brick siding and/or fireplace brick) containing mortar made from Dry Valley tailings material. Appendix B is a compilation of all MVP suspected of containing Dry Valley material. Radon progeny measurements and indoor gamma radiation measurements for the properties measured to date are presented in Appendix B.

4.6 DISCUSSION

By January 1992, approximately 30 out of 786 MVP had been identified as potentially containing Dry Valley mill-related materials. Ten of these 30 properties were found to exceed DOE/EPA standards (U.S.DOE 1987; U.S.EPA 1991); the state of Utah and EPA were notified.

Property-owner statements concerning the origin of building materials have been used to differentiate Monticello mill-related materials from Dry Valley mill-related materials. Additionally, if a structure is known to have been built after 1963, when the Monticello millsite was fenced and stabilized, any radioactive material in the structure is likely to be from a non-Monticello mill source, presumably Dry Valley. Finally, if the property resides on the list provided by the primary contractor mentioned previously, the radioactive material is presumably not related to the Monticello millsite.

The research and study of the Dry Valley millsite and associated tailings provide several points for consideration:

- Dry Valley millsite tailings were, and perhaps still are, readily available to the public before approximately 1984.

- In addition to Dry Valley mill materials, several inactive uranium mines in the Monticello area provide sources of radioactive sand that is readily available to the public. This makes it difficult to determine if all radioactive material not related to the Monticello millsite is of Dry Valley millsite origin.

- Material from both the Dry Valley millsite and other sites was used extensively in the Monticello area by both contractors and residents.

- ^{226}Ra concentrations in Dry Valley mill tailings materials exceed EPA standards; however, indoor radon progeny measurements, both historical EPA measurements and current ORNL measurements, indicate that many of the structures are constructed in such a way that radon levels fall below EPA standards. Therefore, remedial action may not be necessary on many of the properties in question.

- Material from the Monticello millsite was inaccessible to the public after 1963; therefore, it is not likely that structures built after this time contain material from the Monticello millsite.

- The EPA radiological standards used in the MVP project are those set forth for uranium mill tailings. Since the Dry Valley tailings are vanadium tailings, and pre-Manhattan Engineering District era, they may not be subject to UMTRA standards and could be considered NORM.

Moly Corp currently is suggesting that the Dry Valley vanadium tailings be disposed of in the nearby Small Fry mine (Associated Press 1993). The mine offers a unique solution for a number of reasons. First, the vanadium waste is less radioactive than rock in the mine's walls, so there is no increase in the level of radiation. Second, the mine is above the water table so there is little risk of groundwater contamination. Finally, the waste would be permanently isolated from the public since the mine will be sealed at the end of the project. The project is currently under review by the state of Utah Division of Radiation Control.

5. URANIUM MINES

During examination of the Dry Valley millsite, it was noted that several inactive uranium mines exist in the Lisbon Valley area, within two miles of the Dry Valley millsite (Figs. 4 and 5). Each mine contains tailings and rubble readily accessible to the public. The existence of these readily accessible mines serves to illustrate that the Dry Valley millsite is not the only source of radioactive sand that does not come from the Monticello millsite. An example is Monticello property MS00620 where the property owner brought in mine tailings from the Lisbon Valley area to use for mortar in a flagstone patio. Appendices C and D list several properties containing radioactive uranium mine material.

Uranium mines occur throughout Colorado and Utah; several are in the vicinity of Monticello. Many past and present Monticello residents were in the uranium mining business. Therefore, the occurrence of uranium mining equipment and material should come as no surprise.

Uranium generally is mined in the Morrison Formation, which out-crops throughout the western states. The Chinle and Shinarump Formations also contain uranium-bearing strata and are mined in the area (Stokes 1986). Radioactive material from mines is considered a NORM along with material from sources such as mineral processing, coal ash, phosphate waste, fertilizers, oil and gas wastes, water treatment, and geothermal energy wastes.

6. COLLECTOR'S ITEMS AND MISCELLANEOUS SOURCES

Several residents of the Monticello area have rock collections that include radioactive samples of ores such as carnotite, urananite, tyuyamunite, uranothorite, autnite, torbernite. Most of these ores are derived from the deposits of the region. Petrified wood and bone are also abundant in the region and are used for decorative purposes in masonry, garden borders, and rock gardens. Petrified wood and bone becomes radioactive when uranium-rich solution reacts in a reducing environment and uranium replaces the carbon found in these materials. The source formation is usually the Morrison or Chinle for these samples. Again, residents in the area have historically been in the uranium mining business and often possess high-grade samples from various mines. Collectors' items detected during property surveys are listed and described in Appendix D.

Miscellaneous radioactive material found during surveys not related to the Monticello millsite include radium dials, pumice used for decorative purposes, bricks, and cinderblocks. Miscellaneous sources are also listed and described in Appendix D.

7. RADIOACTIVE COAL

Among the sources of radioactive material detected that were unrelated to the Monticello millsite was a radioactive coal-like material that had been used as fill or burned in coal-burning stoves and the ashes disposed of on the property. Because this material exhibits elevated gamma radiation exposure rates, it can potentially exceed DOE guidelines and be subjected to remedial action under the MVP project.

ORNL investigated sources of radioactive coal for two reasons: 1) to avoid the excavation of naturally occurring radioactive material at the expense of DOE during remedial action of MVP, and 2) to inform DOE of potential health risks to the public from material other than that originating at the Monticello millsite.

The methods used to investigate sources of radioactive coal in the Monticello area included: 1) interviewing experts in geological research pertaining to radioactive coal and the Dakota Formation, 2) performing a literature search of coal use and production in the project area, and 3) interviewing property owners concerning the sources of coal-like material on their properties.

7.1 GEOLOGY

Field research revealed radioactive coal seams derived from the Dakota Formation, which outcrops frequently in the general region of Monticello. This coal may have been used as fill material by property owners or as fuel for coal-burnings stoves throughout the history of the town.

Monticello is located on the Colorado Plateau in southeastern Utah, adjacent to the Abajo Mountains. In this province of the Colorado Plateau, the term Dakota Group is used to refer to all predominantly non-marine deposits of lower Cretaceous age. The Dakota Group consists primarily of buff to light-gray sandstone, with interbedded light- to dark-gray sandstone, carbonaceous shales, and a few thin beds of coal. In the Monticello area and much of southeastern Utah, the Dakota Group is divisible into three distinctive units. The lower unit is a cliff-forming, coarse-grained, conglomeratic sandstone. This sandstone rests unconformably on the underlying Burro Canyon Formation. Distinction between the two is sometimes difficult, but can be accomplished with methods not discussed in this report. The middle unit consists of carbonaceous shales, siltstones, and thin coal

beds with a few interbedded sandstone stringers. This middle unit represents a regressive phase of the Cretaceous seaway. The third and uppermost unit of the Dakota Group is a fine-grained, well-sorted, clean quartz sandstone with low-angle course stratification typical of beach deposits.

The middle unit of the Dakota Group contains the carbonaceous shale and coal that are of interest to this investigation. In the town of Monticello, the Dakota has either been eroded away or buried by pediment gravel. However, just outside of Monticello, the Dakota Group outcrops, containing coal seams 5 to 25 cm deep of high enough quality to mine (UGMS 1972). In the early 1900s, the townspeople discovered this source and began mining it. Six locations where coal deposits out-crop in the area of Monticello were sampled (Fig. 6). These deposits are all within 80 km of the town and are easily accessible. It is from these deposits that gamma radiation levels above background and elevated ^{226}Ra concentrations are typically found. The results of the samples are given in Table 2.

7.2 COAL INVESTIGATION RESULTS

Coal samples taken from MVP were from regions of elevated gamma radiation rates or, if no elevated gamma was recorded, from background regions. Properties containing radioactive coal or coaly shale are included in Appendix C. According to local areas residents, coal brought into Monticello was usually purchased locally from the Price, Utah, area. Residents sometimes obtained "free" coal from the Eastland area (Fig. 6) or western Colorado. Samples found to contain coal were taken from MVP. These samples generally contained a mixture of coal or coal ash and soil. The physical characteristics of the coal found in MVP samples differed from coal originating in the Dakota Formation. Some coal separated from the MVP samples was vitreous, black, blocky, and subbituminous, with some wood content, while coal from the outcrops near Monticello was shaly, earthy, friable, and lignitic.

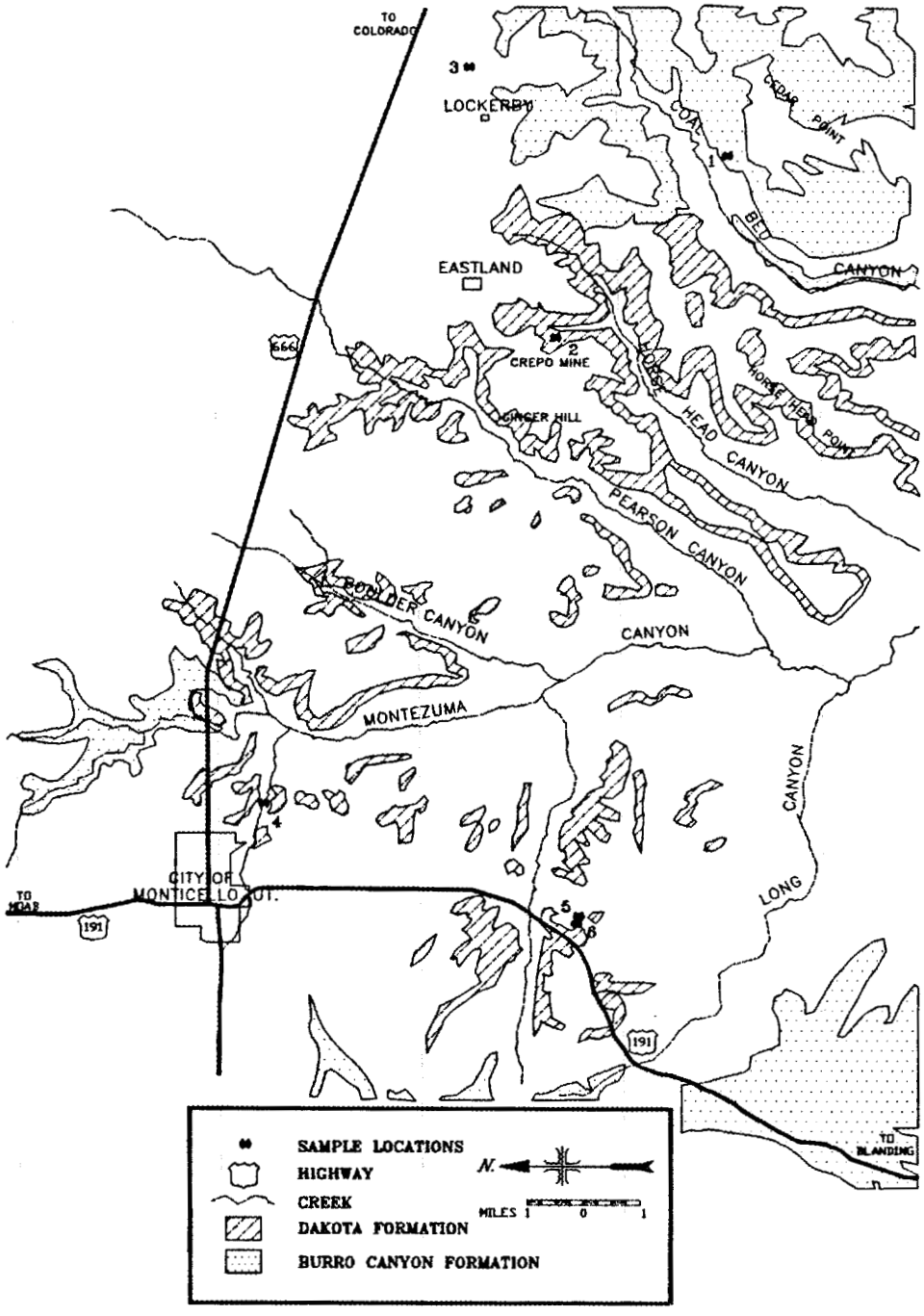

Fig. 6. Locations of coal samples.

Table 2. Locations and measurements of coal samples

Location 1. Coal Bed Canyon, R25E T34S Sect. 17. The Dakota Formation, which is usually distinguished by the change in carbonaceous material, was relatively undifferentiated at this location. Background gamma exposure rates in the sandstone measured 12.31 μR/h. The sample was collected from lignite, grading to carbonaceous shale. Exposure rates in the lignite measured from 25 to 29 μR/h. A second sample of black friable carbonaceous shale was taken at this location, approximately 1.5 m below the conglomerate-coal contact. The exposure rate measured 25 μR/h at this second sample depth. Samples collected here revealed ^{226}Ra concentrations of 2.68 pCi/g and 2.93 pCi/g.

Location 2. Crepo Mine site, T35S R25E Sect. 35. Exposure measurements at the old mine site ranged from 17 to 19 μR/h (19 μR/h inside the mine and 17 μR/h on top of the stockpiled coal). Crepo Mine supposedly began operation about 1929, which is about the time many of the vicinity properties in Monticello were established. Samples collected here revealed ^{226}Ra concentrations of 2.14 pCi/g and 1.48 pCi/g.

Location 3. Road, T35S R24E Sect. 28. This sample was taken in a road cut that appeared to be right above the Morrison Formation and Burro Canyon. Exposure rates measured 22 μR/h at the sample location, dropping to 16 μR/h just above the sampling location where the dark-gray lignitic shale grades to lighter-gray silty shale. These layers interbed, with exposure rate measurements ranging from 20 to 25 μR/h in the darker coal. Samples collected here revealed ^{226}Ra concentrations of 3.16 pCi/g and 1.11 pCi/g.

Table 2. (continued)

Location 4. This shale sample was taken off Cemetery Road, just below Dakota Formation top sand. Shale was gray to black, very carbonaceous, with ore grading to shaly lignite. The exposure rate measured 25 μR/h on contact. Samples collected here revealed ^{226}Ra concentrations of 3.42 pCi/g.

Location 5. Approximately 1.2 km from Recapture Creek, this sample was taken in carbonaceous shale, dark gray to black, grading to shaly lignite. Exposure rates measured 28 μR/h on the surface and 39 μR/h at a depth of 15 cm. The second sample taken at this location was approximately 60 cm below the first. The sample was taken in coal and pediment gravels, with possible sulphur along the fractures and bedding planes. The exposure rate measured 25 μR/h both on the surface and at a 15 cm depth. A third sample was taken on the north side of Highway 91, across the road from the previous two, and was nearly identical to the second sample described above. The three samples collected here revealed ^{226}Ra concentrations of 6.36 pCi/g, 3.47 pCi/g and 8.87 pCi/g respectively.

Location 6. Approximately 2 m stratigraphically above the third sample taken from Location 5, this sample was taken in dark gray to black shale, very carbonaceous, grading to lignite, grading down to coal. The sample collected here revealed a ^{226}Ra concentration of 6.4 pCi/g.

Two samples were 100% coal and were known to have come from the vicinity Price, Utah, according to the property owner. These samples showed <1 pCi/g of ^{226}Ra concentration. Coal from the Price area is part of the Mesa Verde Formation and exhibits low radioactivity. This coal is subbituminous, and its physical properties match the coal separated from some of the MVP soil samples. Other coal samples were from coal purchased at the local feed store that reportedly came from the Cortez area.

It can be concluded that samples of Dakota Formation coal and carbonaceous shale from the Monticello area exhibit above-background gamma radiation levels and ^{226}Ra concentrations. Background gamma radiation exposure rates range from 13 to 17 μR/h in the Monticello area, and the average background ^{226}Ra concentration in soil is 2 pCi/g. Although the coal collected on MVP had no physical characteristics in common with the coal from outcrops, the potential remains for finding coal from the outcrops during excavation.

Since coal from the Dakota Formation was probably used as fuel, coal ash may have been scattered or coal stock-piled on some the properties. A potential for above-background levels of gamma radiation exists if a continuous layer of coal-like material, a large stockpile of coal-like material, or coal ash is encountered.

If a continuous layer or stockpile of coal with elevated gamma radiation is found on a property during an inclusion survey or remedial action verification, samples should be taken and analyzed. If the ^{226}Ra concentration is above 5 pCi/g, an analysis should be performed to determine if uranium and radium are in equilibrium. A uranium-radium equilibrium indicates that the sample is a naturally occurring source rather than mill tailings, which exhibit a uranium-radium ratio of less than 1.

8. CONCLUSION

Figure 7 displays the occurrences of non-Monticello millsite radioactive materials detected during property surveys. Decorative rock used for landscaping was the largest occurrence, followed by uranium ore samples. Vanadium tailings from the Dry Valley millsite composed the third most frequent occurrence.

Remedial action activities will continue in Monticello through the year 1997, when the site is scheduled to be removed from the NPL. Encounters with naturally occurring radioactive material and other radioactive sources not related to the Monticello millsite will continue to occur. Awareness of these materials is essential to allow DOE to forecast the additional costs and schedule changes associated with the discussion of remediating them. Also, material that may pose a health threat to the public should be revealed to other regulatory agencies for consideration.

Chart values represent occcurrences and not individual properties.

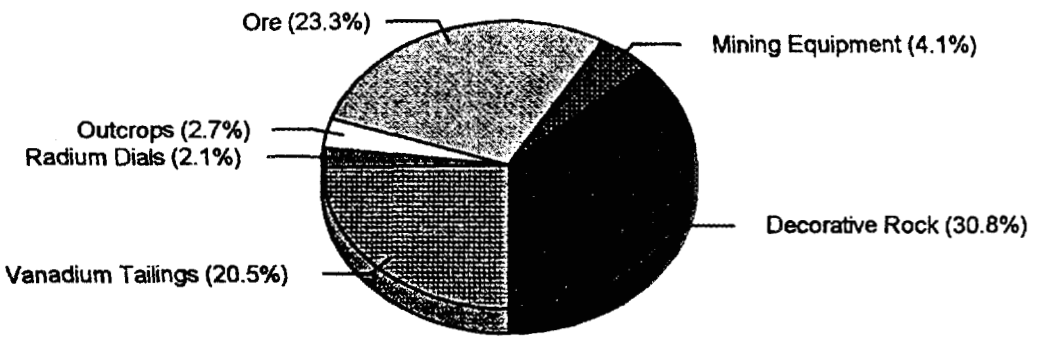

Fig. 7. Non-Monticello-millsite occurrences.

REFERENCES

Anderson, L. F. 1984. Memorandum to G. Morris, Union Oil Company, Parachute, Colo., August 16. State of Utah Department of Health.

Associated Press. 1993. Of Mines and Men: Old Uranium Mine to Take Low-Level Radioactive Waste. *Rocky Mountain Pay Dirt*, January 1993.

Johnson, R. H. 1990. Resolution of the Monticello Uranium Mill Tailings Legal Action. In *Environmental Radiation and Public Policy Topical Symposium Proceedings*, Lake Meade Chapter of the Health Physics Society, Las Vegas, Nev.

Little, C. A., and B. A. Berven. 1985. *Results of the Survey Activities and Mobile Gamma Scanning in Monticello, Utah*. ORNL/TM-9738. Oak Ridge National Laboratory, Oak Ridge, Tenn.

Minobras. 1978. *Uranium Guidebook for the Paradox Basin, Utah–Colorado*. Minobras, Dana Point, Calif.

ORNL. 1990. *Pollutant Assessments Group Procedures Manual*. ORNL-6645. Oak Ridge National Laboratory, Grand Junction, Colo.

Perkins, C. A., M. G. Neilson, and L. B. Jones. 1968. *Saga of San Juan*. San Juan County Daughters of Utah Pioneers.

Rust Geotech. 1993. *Field Assessments Procedures Manual*. Revision 08. Rust Geotech, Grand Junction, Colo.

Stokes, W. L. 1986. *Geology of Utah.* Utah Museum of Natural History. University of Utah and Utah Geological and Mineral Survey, Salt Lake City, Utah.

UGMS. 1972. Utah Geological and Mineralogical Survey, Monograph Series No. 2., Salt Lake City, Utah.

UNC Geotech. 1989a. *Monticello Utah, Federal Facilities Agreement Work Plan.* UNC Geotech, Grand Junction, Colo.

UNC Geotech. 1989b. *Remedial Investigation for the Monticello Uranium Mill Tailings Site, Monticello, Utah.* Revised draft. DOE/ID/12584-21, UNC/GJ-MRAP-2. UNC Geotech, Grand Junction, Colo.

U.S.DOE. 1987. *Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program (FUSRAP).* Revision 2. U. S. Department of Energy, Washington, D.C.

U.S.EPA. 1984. *EPA Survey of Possible Mill Tailings Contamination in Monticello, Utah.* U. S. Environmental Protection Agency, Region VIII, Denver, Colo.

U.S.EPA. 1991. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR Part 192). *Federal Register*, 48:49547.

USGS. 1987. *Sandstone Draw, Utah.* 7.5-minute series topographic map. Provisional Edition. U. S. Geological Survey, Reston, Va.

ACRONYMS AND INITIALISMS

AEC	Atomic Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
DOE	Department of Energy
EM	Office of Environmental Restoration and Waste Management
EPA	Environmental Protection Agency
FFA	federal facilities agreement
FUSRAP	Formerly Utilized Sites Remedial Action Program
GJ	Grand Junction
MRAP	Monticello Remedial Action Project
MVP	Monticello vicinity properties
NORM	naturally occurring radioactive material
NPL	National Priorities List
ORNL	Oak Ridge National Laboratory
PAG	Pollutant Assessments Group
RDC	radon daughter concentration
SARA	Superfund Amendment and Reauthorization Act
SFMP	Surplus Facilities Management Program
UNC	United Nuclear Corporation
UMTRAP	Uranium Mill Tailings Remedial Action Project
WL	working level

APPENDIX A

PROPERTIES AFFECTED BY MASONRY CONTRACTOR, 1975 TO 1989

Table A-1. Properties affected by masonry contractor, 1975 to 1989

Location No.	Year of Construction	Type of Construction
MS00002	1978	Veneer
MS00002	1985	Veneer/garage
MS00004	1980	Fireplace/stove
MS00006	1978	Fireplace
MS00006	1979	Fireplace
MS00006	1980	Veneer
MS00007	1976	Veneer/fireplace
MS00009	1979	Veneer/fireplace
MS00016	1980	Brickwork/windows
MS00036	1974	Slump block building
MS00036	1977	Block
MS00037	1981	Slump block
MS00037	1981	Slump block
MS00055	1973	Rockwork
MS00057	1979	Veneer/apartments
MS00057	1980	Park plaza veneer
MS00059	1984	Block/plaster
MS00099	1979	Fireplace
MS00100	1976	Block addition
MS00111	1975	Block wall
MS00115	1979	Brick/stucco
MS00118	1980	Brick veneer
MS00119	1979	Veneer
MS00120	1977	Veneer
MS00121	1979	Veneer
MS00124	1989	Fireplace face
MS00125	1979	Rockwork/wall
MS00144	1976	Chimney/fireplace

Table A-1. (continued)

Location No.	Year of Construction	Type of Construction
MS00166	1983	Chimney
MS00169	1980	Veneer
MS00169	1980	Block chimney
MS00169	1985	Veneer
MS00175	1980	Chimney
MS00199	1989	Brick fireplace
MS00205	1984	Chimney/fireplace
MS00218	1975	Block vault
MS00218	1975	Slump block
MS00261	1981	Rock/planter
MS00261	1983	Block veneer
MS00265	1989	Foundation repair
MS00266	1982	Veneer/chimney
MS00268	1989	Repair retaining wall
MS00268	1975	Rockwork on pavement
MS00275	1980	Veneer/chimney
MS00276	1975	Brick veneer
MS00284	1976	Fireplace
MS00295	1983	Fill in door
MS00307	1981	Chimney
MS00307	1983	Block foundation
MS00323	1979	Veneer
MS00359	1974	Block foundations
MS00371	1975	Veneer/office
MS00387	1985	Brick wall/stove
MS00406	1974	Fireplace
MS00419	1980	Firewall/block
MS00425	1985	Veneer/firestation
MS00426	1981	Fill in window
MS00426	1989	Veneer storage building

Table A-1. (continued)

Location No.	Year of Construction	Type of Construction
MS00433	1981	Block repair/apartment
MS00433	1981	Block repair/apartment
MS00455	1982	Block/store
MS00455	1984	Block foundation
MS00461	1976	Veneer
MS00471	1973	Fireplace
MS00475	1975	Fireplace
MS00475	1977	Fireplace
MS00482	1975	Chimney
MS00482	1979	Firplace/chimney
MS00486	1973	Brick veneer
MS00499	1980	Chimney/fireplace
MS00514	1974	Fill in window
MS00546	1973	Fireplace/chimney
MS00572	1980	Veneer/chimney
MS00584	1973	Brick fireplace
MS00587	1974	Block building
MS00590	1973	Brick veneer
MS00601	1980	Wainscot/carport
MS00607	1982	Veneer/porch
MS00609	1976	Veneer
MS00617	1983	Fireplace face
MS00621	1980	Fireplace
MS00628	1975	Chimney/extension
MS00632	1974	Veneer/chimney/fireplace
MS00632	1984	Veneer/addition
MS00633	1988	Fireplace face
MS00633	1983	Veneer/chimney/fireplace

Table A-1. (continued)

Location No.	Year of Construction	Type of Construction
MS00634	1976	Veneer
MS00634	1979	Veneer
MS00635	1989	Block foundation
MS00635	1978	Fireplace
MS00637	1979	Chimney
MS00643	1989	Brick/stove
MS00644	1980	Chimney
MS00644	1980	Chimney
MS00645	1979	Veneer
MS00645	1979	Veneer
MS00646	1982	Chimney
MS00670	1974	Veneer/fireplace
MS00672	1974	Brick veneer
MS00750	1977	Fireplace
MS00754	1985	Block walls
MS00754	1989	Block/front doors
MS00756	1989	Plaster remodel
MS00756	1981	Veneer/boiler building
MS00756	1976	Doors/blockwork
MS00757	1974	Fireplace/rock
MS00805	1978	Fireplace/chimney
MS00810	1975	Brick veneer
MS00826	1985	Block walls
MS00826	1988	Block wall
MS00830	1978	Fireplace/chimney
MS00850	1977	Fireplace
MS00852	1980	Decorative wall
MS00852	1977	Veneer
MS00856	1974	Brick veneer
MS00859	1976	Veneer/chimney,

Table A-1. (continued)

Location No.	Year of Construction	Type of Construction
		Fireplace/retaining wall
MS00889	1983	Veneer
MS00936	1985	Block foundation
MS00945	1976	Veneer/fireplace
MS00948	1975	Rock/block/fire
MS00950	1974	Fireplace
MS00973	1985	Block in doorway
MS01058	1989	Fireplace face
*Eastland	1973	Rockwork/planter
Properties	1974	Block work
	1974	Brick veneer
	1974	Chimney/fireplace
	1975	Brick veneer
	1976	Veneer
	1978	Veneer
	1978	Veneer
	1978	Veneer
	1978	Veneer
	1978	Veneer
	1978	Block
	1978	Veneer
	1978	Veneer/wall
	1978	Veneer
	1979	Block
	1979	Veneer
	1980	Stove
	1980	Veneer
	1980	Block chimney
	1980	Chimney
	1980	Brick entry

Table A-1. (continued)

Location No.	Year of Construction	Type of Construction
	1980	Lamp posts
	1980	Block chimney
	1980	Remodel
	1981	Pillars/planter
	1981	Fireplace/chimney
	1981	Veneer
	1973	Fireplace
	1983	Block walls
	1984	Chimney/fireplace
	1984	Chimney/Blanding
	1984	Chimney/Blanding
	1985	Veneer/chimney
	1985	Veneer/chimney
	1985	Block stairwell
	1985	Block chimney
	1985	Block
	1989	Rock on garage
	1989	Veneer storage building

* Eastland is a small community located approximately 13 km southeast of Monticello and is outside the MVP project boundary.

APPENDIX B

DRY VALLEY MILLSITE PROPERTIES

Table B-1. Dry Valley millsite properties

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00002	Include	RDC >0.02 WL	Brick siding	0.0237	mortar	Contractor list
MS00004	Include	Hot spot guideline	None	-	point source	Contractor list
MS00006	Exclude	RDC >0.02 WL	Brick siding/ hearth	0.0075 0.01	mortar	Contractor list
MS00007	Exclude	RDC >0.02 WL	Brick siding	0.003	mortar	Contractor list
MS00009	Include	RDC >0.02 WL	Brick siding	0.037 0.009	mortar	Contractor list
MS00015	Exclude	RDC <0.02 WL	Brick siding	0.0059	mortar	Contractor list; did brickwork on the addition.
MS00016	Include	^{226}Ra >5 pCi/g	Brick siding	0.014*	soil sample	Contractor list; historical EPA results*
MS00020	Include	Hot spot guideline	Wall in shed	-	elevated mortar in sandbox	Owner stated sand used for mortar was from Dry Valley.
MS00035	Exclude	-	-	-	tailings	The base of a paint mixer is filled with tailings.
MS00036	Exclude	RDC <0.02 WL	Brick siding	0.0094	mortar	Contractor list
MS00037	Exclude	-	Brick wall	-	mortar	Contractor list

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00039	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	Brick wall	-	point source mortar	Multiple point sources; owner was not available for interior survey; structure was built in the 1950s.
MS00057	Exclude	RDC <0.02	Brick siding	0.0012	mortar	Contractor list
MS00059						Historically included property rescinded to EPA; built before 1948; adobe walls elevated.
MS00115	Include	^{226}Ra >5 pCi/g	Mortar and stucco	-	mortar stucco	Contractor list
MS00116	Include	^{226}Ra >5 pCi/g; RDC >0.02 WL	Brick siding	0.0388 0.0123	mortar	Owner stated sand used for mortar was from Dry Valley.
MS00117	Include	^{226}Ra >5 pCi/g	-	-	mill tailings	Owner of MS00116 stated sand for construction was dumped on MSOO117.
MS00118	Exclude	RDC <0.02 WL	Brick siding	0.0019	mortar	Contractor list
MS00119	?	?	Brick siding	-	mortar	Contractor list; owner refused RDC; historical RDC measurements >0.02 WL
MS00120	Exclude	-	Brick retaining wall	-	mortar	Contractor list

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00121	Exclude	RDC <0.02	Brick siding	0.004 0.011	mortar	Contractor list
MS00123	Exclude	RDC <0.02 WL	Brick siding	0.0155	mortar	Owner stated that the house was built in 1978.
MS00124	Include	^{226}Ra >5 pCi/g	Fireplace/chimney	0.0067	mortar	Contractor list
MS00125	Include	RDC >0.02 WL		0.1332		
MS00127	Include	^{226}Ra >5 pCi/g	Chimney	0.0031*	mortar	Owner stated sand for mortar was from Dry Valley. 9-day grab sample.*
MS00144	Include	^{226}Ra >5 pCi/g	Fireplace/brick siding	0.016*	windblown; mortar	Contractor list EPA measurements*
MS00169	Include					Contractor list; UNC surveyed as a spillover; ORNL performed no field work.
MS00186	Include	^{226}Ra >5 pCi/g	Brick siding	-	mortar	Owner stated that the house was built after 1976.
MS00218	Include	Hot spot guideline	-	-	soil	Contractor list
MS00233	Include	Hot spot guideline; ^{226}Ra >5 pCi/g; indoor gamma incl.	Brick siding	-	soil/mortar	Owner stated that the house was built in the 1950s.
MS00237	Exclude	-	Hearth/fireplace	-	mortar	Owner stated that contractor built.

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00259	Exclude	-	Brick wall	-	mortar	Contractor did repair on brick wall and replaced with elevated mortar.
MS00266	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	Chimney; brick siding	-	mortar	Contractor list; visible tailings and buckets of elevated mortar remained.
MS00271	Include	RDC >0.02 WL	Concrete block	0.0303	mortar	Built in 1976; contractor is thought to have built.
MS00275	Include	^{226}Ra >5 pCi/g	Brick siding/ chimney	-	soil/mortar	Contractor list
MS00281	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	Rock wall; retaining wall	-	mortar	Owner stated sand used for mortar was from Dry Valley.
MS00284	Include	^{226}Ra >5 pCi/g	Interior brick wall	-	mortar	Contractor list
MS00290	Exclude	-	Cinder block chimney	-	mortar	Chimney was built in 1975.
MS00307	Exclude	-	Block foundation chimney	-	mortar	Contractor list
MS00313	Include	Hot spot guideline	-	-	tailings	A barrel of tailings is located on the property. Owner does not know the origin of the barrel.
MS00314	Include	^{226}Ra >5 pCi/g	Fireplace; concrete footers in garage	0.0015 0.0043	mortar	Owner stated sand for mortar was from Dry Valley

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00325	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	Brick siding; fireplace/hearth	-	mortar	Owner stated that the house was built in 1982.
MS00328	Include	Hot spot guideline	Fireplace; rock walkway; wall	-	mortar	Owner stated that sand for mortar was from Dry Valley.
MS00330	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	Elevated cinder block foundation	-	soil/mortar	Owner stated that sand for mortar was from Dry Valley.
MS00338	Include	Indoor gamma inclusion	Stucco walls and brick siding	-	mortar	Owner stated that the house was built in 1948.
MS00433*	Include	RDC >0.02 WL	Brick siding	0.0486	mortar	Contractor list
MS00451	Include	Hot spot guideline	-	-	pile of mortar	Associated with MS00116 and MS00117, which have Dry Valley contamination.
MS00455*	Pending	Unknown at this time	Block walls	0.0052	mortar	Contractor list
MS00461	Exclude	RDC <0.02 WL	Brick wall	0.0052	mortar	Contractor list
MS00475	Include	RDC >0.02 WL	Brick hearth and walls	0.026	mortar	Contractor list
MS00482	Include	Indoor gamma inclusion	Brick hearth and walls	0.010	mortar	Contractor list
MS00490	Exclude	-	Brick hearth/ brick siding	-	mortar	Owner stated that contractor built.
MS00531	Exclude	RDC <0.02 WL	Brick siding	0.0068	mortar	Owner stated that contractor built.

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00551	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	-	-	tailings; sandy soil	Owner stated that he put Dry Valley tailings in a sandbox.
MS00557	Exclude	RDC <0.02 WL	Fireplace	0.005	mortar	Owner stated that contractor built.
MS00572	Exclude	-	Cinder block wall	-	mortar	Block wall adjoining MS00573; contractor did brick siding and chimney on the property.
MS00600	Include	Indoor gamma inclusion	Brick work	-	mortar	Contractor did the brickwork.
MS00601	Exclude	-	Brick work on carport	-	mortar	Contractor did this brickwork.
MS00620	Include	Hot spot guideline	Mortar in flagstone patio	-	mortar	Owner stated that sand for mortar was from Dry Valley.
MS00621	Exclude	RDC <0.02 WL	Fireplace	0.0167	mortar	Contractor list
MS00624	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	-	-	pile of brick and mortar	Construction waste; most likely Dry Valley in origin as this is a property on North Creek Drive.
MS00628	Exclude	-	-	-	-	Contractor list; brickwork was the highest outdoor gamma.
MS00637			Wall behind woodstove	0.014	mortar	

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00644	Exclude	-	Chimney and fireplace	-	mortar	Contractor list
MS00724	Exclude	-	Brick hearth	-	mortar	Owner stated that contractor did the brickwork.
MS00750	Include	Hot spot guideline; ^{226}Ra >5 pCi/g	-	-	soil	Contractor list; fireplace was the highest indoor gamma
MS00810				0.006	mortar	Owner stated contractor built.
MS00820			Cinderblock footing	0.005	mortar	Owner stated that contractor built.
MS00825	Exclude	-	-	-	-	Contractor list; block work was not elevated.
MS00850	Exclude	-	Brick siding	-	mortar	Contractor list; brick fireplace slightly elevated.
MS00852			Fireplace	0.017	mortar	Owner stated contractor built.
MS00858	Include	^{226}Ra >5 pCi/g	-	-	tailings	Contractor is the owner and stated that sand for the mortar was probably from Dry Valley.
MS00859	Include	RDC >0.02 WL	Brick fireplace	0.0400	mortar	Fireplace mortar utilized Dry Valley tailings; outside masonry used tailings from Mexican Hat.

Table B-1. (continued)

Location Number	Decision[a]	Guidelines	Structure	RDC, WL	Source	Proof/Comments
MS00896	Exclude	-	Tailings near patio	-	-	Owner stated that he did the patio work in 1976.
MS00917	Include	Hot spot guideline	Sandstone pad and water fountain	-	mortar	Mortar sample included property. Origin of tailings and time of construction unknown.
MS00945				0.005		Owner stated contractor built.
MS01004	Exclude	-	-	-	-	Bricks found on property are suspected to be from remodeling of MS00115.
MS01058			Fireplace		mortar	Owner stated that contractor built.

[a] Include/Exclude refers to the decision by the Department of Energy to include a property for remedial action based on whether or not radiation levels exceed guidelines. If the guidelines were not exceeded the property is excluded.

* This information was obtained from Chem Nuclear Geotech radiological survey data.

RDC = radon daughter concentration
WL = working level
EPA = Environmental Protection Agency

APPENDIX C

MISCELLANEOUS AND NATURALLY OCCURRING RADIOACTIVE MATERIAL

Table C-1. Miscellaneous and naturally occurring radioactive material

Location Number	Description	Exposure Rate, μR/h	Decision[a]	Comments
MS00017	Pile of bricks	19 to 25	Exclude	EPA notified
MS00058	Soil moisture density gauges	80	Exclude	Licensed by the state of Utah
MS00172	Decorative pumice	16 to 17	Exclude	
MS00217	Probe used for calibration in ore exploration	>1400	Include	EPA notified; included on hot spot guidelines
MS00394	Stack of bricks	17 to 22	Include	
MS00470	Radium dial compass	880	Exclude	EPA notified
MS00473	Pile of bricks	17	Exclude	
MS00479	Bricks on house	17	Exclude	
MS00487	Tarp from mine	17	Exclude	
MS00502	Bricks on house	20	Exclude	
MS00505	Bricks on house	17	Exclude	
MS00507	Bricks on house	16 to 17	Exclude	
MS00537	Cinder block on garage	16	Exclude	
MS00522	Coal	18	Exclude	
MS00555	Cinder block on house	17	Exclude	
MS00556	Bricks on house	17	Exclude	
MS00558	Bricks on house	16	Exclude	
MS00559	Pile of firebrick	25	Exclude	

Table C-1. (continued)

Location Number	Description	Exposure Rate, μR/h	Decision[a]	Comments
MS00561	Firebrick planter	17	Exclude	
MS00569	Radium dial compass	170	Exclude	EPA notified
MS00573	Cinder block wall and bricks on house	16	Exclude	
MS00604	Pumice/cinder block wall	22 17	Exclude	
MS00627	Bricks on house fireplace	17	Exclude	
MS00636	Cinder block foundation	17	Exclude	
MS00641	Stack of firebrick	20	Exclude	
MS00729	Bricks on house	16	Exclude	
MS00732	Concrete block fence	16 to 17	Exclude	
MS00768	Cinder block/ steel pipe	19 to 25 58	Include	
MS00786	Contaminated door	66	Exclude	Geotech was to remove door.
MS00787	Logging probe with encased source	660	Exclude	EPA notified
MS00832	Firebrick on house	17	Exclude	
MS00838	Cinder block wall	17	Exclude	
MS00903	Pallets of brick	22	Exclude	
MS00915	Coal ash pile	17	Exclude	
MS00970	Radium dial	170	Include	

Table C-1. (continued)

Location Number	Description	Exposure Rate, μR/h	Decision[a]	Comments
MS00958	Mining equipment/pickup bed with ore	19 to 58 19 to 226	Include	
MS00974	Shale	17	Exclude	
MS00995	Dakota coal	19	Exclude	

[a] Include/Exclude refers to the decision by the Department of Energy to include a property for remedial action based on whether or not radiation levels exceed guidelines. If the guidelines were not exceeded, the property is excluded.

EPA = Environmental Protection Agency

APPENDIX D

COLLECTORS' ITEMS AND OTHER POINT SOURCES

Table D-1. Collectors' items and other point sources

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00013	Ore	Decorative walls and pillar to Happy Jack Mine	36 to >1200	Exclude	EPA notified
MS00017	Petrified wood, dinosaur bone	Decorative rock	16 to 66 73	Exclude	EPA notified
MS00025	Ore, petrified wood, dinosaur bone	Rock garden	1460 51 36	Include	
MS00026	Petrified wood	Decorative rock	17	Exclude	
MS00030	Ore, petrified wood, dinosaur bone	Rock collection, rock garden	>960	Include	Refused survey
MS00032	Ore	Decorative rock in fireplace	100	Exclude	RDC <0.02 WL
MS00038	Ore	Uranium book ends	>1200	Include	
MS00119		Rock garden	22 to 1000	Include	Refused RDC measurements
MS00120	Petrified wood	Decorative rock	29	Exclude	EPA notified
MS00128	Ore	Decorative samples	57, 95	Include	
MS00173	Petrified wood	Decorative rock	22	Exclude	

Table D-1. (continued)

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00186		Decorative border of rocks	95 to 230	Include	
MS00187	Petrified wood, dinosaur bone	Decorative rock border	25 to 29	Include	
MS00194	Petrified wood	Decorative rock	41	Include	
MS00215	Ore	Rock collection, urananite	25, 600	Exclude	EPA notified
MS00217 MS00234	Ore	Decorative ore cart, pitchblend	>1400	Include Include	Cart between properties, EPA notified
MS00258	Ore	Sample	880	Exclude	EPA notified
MS00263	Ore, petrified wood	Rock collection	360 73	Exclude	
MS00268	Ore	Samples on display	95, >1200	Exclude	Senior center, EPA notified
MS00281	Petrified wood	Decorative rock	29	Include	
MS00285	Ore	Samples	170, 1500	Exclude	School district, EPA notified
MS00304	Ore, petrified wood	Rock garden	36, 33, 110 240	Include	
MS00307	Sandstone	Decorative rock	19	Exclude	

Table D-1. (continued)

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00310	Ore	Rock collection, Happy Jack Mine	>1200		Recommended exclusion
MS00346	Petrified wood, dinosaur bone	Rock garden	>1200	Exclude	
MS00382	Ore	Pitchblend	>1200	Include	
MS00383	Ore	Pitchblend	>1200	Exclude	EPA notified
MS00402	Ore, petrified wood	Rock collection	17 to 22, 44, 26 >1200	Exclude	EPA notified
MS00424	Sandstone	Decorative rock	66	Include	
MS00468	Petrified wood	Decorative rocks	25 to 29	Exclude	
MS00469	Ore	Sample	660	Exclude	EPA notified
MS00470					
MS00478	Petrified wood	Decorative rock	29	Exclude	RDC <0.02 WL
MS00480	Dinosaur bone	Rock garden	28 to 880	Exclude	EPA notified
MS00512	Ore, petrified wood	Decorative rocks	150, 300 25, 80	Include	
MS00517	Petrified wood	Decorative rock	110	Include	
MS00530	Ore	Sample, Happy Jack Mine	>1400	Exclude	EPA notified

Table D-1. (continued)

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00535	Petrified wood	Decorative rock	35	Include	
MS00545	Ore	Samples	300	Exclude	
MS00555	Petrified wood, dinosaur bone	Decorative rock	19		Recommended exclusion
MS00557					
MS00560	Ore	Sample	300	Exclude	
MS00562	Petrified wood	Decorative rock	25	Exclude	
MS00569	Petrified wood	Decorative rock	17 to 51, 51	Exclude	EPA notified
MS00570	Ore	Sample	>1200	Exclude	EPA notified
MS00576	Dinosaur bone	Decorative rock	36	Exclude	RDC <0.02 WL
MS00577	Petrified wood	Decorative rock	22	Exclude	
MS00581	Petrified wood	Decorative rock	95	Exclude	
MS00607					
MS00616	Ore	Rock collection	22 to >1400	Exclude	
MS00617	Petrified wood	Decorative rock	22	Exclude	
MS00619	Petrified wood	Decorative rocks	17 to 22	Exclude	

Table D-1. (continued)

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00626	Petrified wood, sandstone	Rock garden	44	Exclude	EPA notified
MS00630	Dinosaur bone	Decorative rock	36	Exclude	EPA notified
MS00653					
MS00683	Petrified wood	Decorative rocks	22 to 95	Exclude	EPA notified
MS00736	Petrified wood	Decorative rock	66	Exclude	EPA notified
MS00740	Petrified wood	Decorative rock	44	Exclude	EPA notified
MS00752	Ore	Samples	300, 600	Exclude	EPA notified
MS00754	Ore, petrified wood	Classroom collection	300 150	Exclude	School district, EPA notified
MS00762	Ore	Sample	150	Exclude	
MS00773					
MS00787	Ore	Pitchblend	73, >1200	Exclude	
MS00788	Petrified wood	Decorative rock	51	Exclude	EPA notified
MS00814	Petrified wood	Decorative rocks	17, 22	Exclude	EPA notified
MS00819	Ore	Piles of ore	300, >1200	Exclude	
MS00823	Ore	Samples, Temple Mine	590 to >1200	Exclude	EPA notified

Table D-1. (continued)

Location Numbers	Type	Description	Gamma Radiation Exposure Rate, μR/h	Decision[a]	Comments
MS00824	Ore	Sample, Happy Jack Mine	372	Exclude	EPA notified
MS00827	Petrified wood	Decorative rock	29	Exclude	
MS00828	Ore, petrified wood, dinosaur bone	Rock garden	160 19 to 120	Exclude	EPA notified
MS00850	Ore	Samples	32, 100	Exclude	EPA notified
MS00861	Petrified wood	Decorative rock	300	Include	
MS00970	Ore, dinosaur bone	Decorative rock	33 to 170	Include	
MS01058		Rock garden, decorative rock in fireplace	22 58	Include	RDC >0.02 WL
MS01065	Ore	Sample	740		Recommended exclusion

[a] Include/Exclude refers to the decision by the Department of Energy to include a property for remedial action based on whether or not radiation levels exceed guidelines. If the guidelines were not exceeded, the property is excluded.

EPA = Environmental Protection Agency
RDC = radon daughter concentration

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