Final Remedial Investigation Report

Uravan Uranium Project (Union Carbide)
Superfund Site
Uravan, Colorado

EPA Contract No. EP-W-05-049
Work Assignment No: 354-TATA-0846

Prepared by:
CDM Federal Programs Corporation

October 2017

RESPONSE ACTION CONTRACT
FOR REMEDIAL, ENFORCEMENT OVERSIGHT, AND NON-TIME
CRITICAL REMOVAL ACTIVITIES AT SITES OF RELEASE OR
THREATENED RELEASE OF HAZARDOUS SUBSTANCES
IN EPA REGION VIII

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Prepared for:
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Acronyms

ACL	alternate concentration limit
ALARA	as low as reasonably achievable
ARAR	applicable or relevant and appropriate requirement
ARL	appropriate remediation level
bgs	below ground surface
BLM	U.S. Department of the Interior Bureau of Land Management
Ca	calcium
CCC	Colorado Climate Center
CCR	Code of Colorado Regulations
CD	Consent Decree
CDM Smith	CDM Federal Programs Corporation
CDOT	Colorado Department of Transportation
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
Cl	chloride
cm	centimeter
COC	contaminant of concern
CRPs	Club Ranch Evaporation Ponds
DOE	U.S. Department of Energy
E2	E2 Inc.
EPA	U.S. Environmental Protection Agency
FS	feasibility study
gpd/ft	gallons per day per foot
HDPE	high density polyethylene
IC	institutional control
IEUBK	Integrated-Exposure Uptake Biokinetic
K	potassium
LM	Legacy Management
m^2	square meter
MCL	maximum contaminant level
MFG	MFG, Inc.
Mg	magnesium
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MOA	memorandum of agreement
mrem/yr	millirem per year
µg/kg	micrograms per kilogram
µR/hr	microroentgens per hour
Na	sodium
NH_3	ammonia
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NO_3	nitrate
NORM	naturally occurring radioactive material

NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	United States Nuclear Regulatory Commission
pCi/g	picocuries per gram
pCi/L	picocuries per liter
pCi/m^2s	picocuries per square meter per second
P.L.	Public Law
PMF	probable maximum flood
PMP	probable maximum precipitation
PRG	preliminary remedial goal
RA	remedial action
RAO	remedial action objective
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RG	remedial goal
RI	remedial investigation
ROD	Record of Decision
RP	responsible party
SDWA	Safe Drinking Water Act
Site	Uravan Uranium Project (Union Carbide Corp.) site
SO_4	sulfate
TDS	total dissolved solids
UCC	Union Carbide Corporation
Umetco	Umetco Minerals Corporation
UMTRCA	Uranium Mill Tailings Radiation Control Act
U.S.C.	United States Code
VLDPE	very low-density polyethylene
WA	work assignment

Section 1
Introduction

CDM Federal Programs Corporation (CDM Smith) has prepared this remedial investigation (RI) report for the Uravan Uranium Project (Union Carbide Corp.) site (Site), a U.S. Environmental Protection Agency (EPA) Superfund Site located in Montrose County, Colorado. This RI report was developed, in accordance with Task 1.9, Work Assignment (WA) 354-TATA-0846, EPA Contract EP-W-05-049, to supplement the Site administrative record for Record of Decision (ROD) development and to evaluate the potential need for additional components.

1.1 Purpose and Approach

The approach developed in this RI report is not strictly consistent with EPA guidance for RI development (EPA 1988). Instead of summarizing Site conditions and nature and extent of contamination to support remedy evaluation, this RI report summarizes previously completed RA activities and describes residual contamination left-in-place to finalize the Site ROD.

The Uravan Uranium Millsite Remedial Action Plan (RAP), as amended, was considered at the time the functional equivalent of an RI/feasibility study (FS) and ROD for RA work completed in accordance with the Consent Decree (CD). The CD was executed in 1986 between the State of Colorado and Umetco Minerals Corporation (Umetco) (i.e., the responsible party for Site work) and has had several amendments with 2005 being most recent (Umetco 2005). The RAP is attached as Appendix I to the CD, Order, Judgment, and Reference to a Special Master Filed in the United States District Court, Civil Action No. 83C2384, State of Colorado, Plaintiff, vs. Union Carbide Corporation, a New York Corporation, and Umetco Minerals Corporation, a Delaware Corporation, Defendants.

1.2 Site Background and Regulatory Framework

The Site is located in a rural part of Montrose County, Colorado approximately 90 miles southwest of Grand Junction, as shown in Figure 1-1. The Site was proposed to the National Priorities List (NPL) in October 1984 and listed in June 1986. The approximately 700-acre Site is not divided into operable units, nor were the Site boundaries ever formally defined. The Site areas include the former processing areas, the former Town of Uravan, and surrounding areas as shown on Figure 1-2. Colorado Scenic Highway 141 is located along and partially through the eastern portion of the Site. The San Miguel River runs through the Site.

A radium-recovery plant began operating in the Site area in 1912. From the 1930s until 1984, various plants operated as uranium and vanadium processing facilities. The mill was placed on standby status in November 1984, and operations were never resumed prior to closure. The facility was licensed, initially by the Atomic Energy Commission, then the United States Nuclear Regulatory Commission (NRC), and more recently by Colorado Department of Public Health and Environment (CDPHE) in its role as an agency within an Agreement State. There is currently the CDPHE Radioactive Materials License 660-02 in effect.

A memorandum of agreement (MOA) signed in April 1986 between the State of Colorado and Region 8 designated the State to be the lead for this Site (EPA 1986). In the MOA, the State agreed to follow the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) process. Accordingly, remedial work at the Site was accomplished under a CD/RAP, which EPA is not a party to, and under the CDPHE Radioactive Materials License 660-02. By stipulated agreement between the CD parties, Umetco (a wholly owned subsidiary of UCC was added as a defendant in 1986. Umetco is the responsible party (RP) for Site work. The State continues to be the lead agency for the Site with EPA as the support agency, with the exception that EPA is the lead agency on the RI/Focused Feasibility Study/Proposed Plan/Record of Decision/Five-Year Review process.

Operations at the Site left a large volume of wastes, which contaminated air, soil, and groundwater near the plant and in the San Miguel River. Solid wastes totaled over 10 million cubic yards and contained radioactive elements, metals, and inorganic compounds. Liquid wastes from seepage collection and groundwater extraction systems totaled over 350 million gallons at the end of 2004. The contaminants included radioactive products such as raffinates (liquid wastes from the uranium processing operations), raffinate crystals (primarily ammonium sulfate compounds), and mill tailings containing uranium and radium. Other chemicals in the tailings and groundwater included heavy metals (lead, arsenic, cadmium, and vanadium), thorium, and residual salts. EPA listed the Site on the NPL in 1986, and the cleanup remedies from the 1987 RAP (as amended) included the following:

- Capping and revegetating nearly 10 million cubic yards of radioactive tailings.
- Onsite disposal of 530,000 cubic yards of radioactive raffinate crystals.
- Eliminating process ponds.
- Pumping and treating contaminated groundwater.
- Securing 12 million yards of tailings waste along the San Miguel River.
- Dismantling the two mills and placing all old building demolition materials in a secure area.
- Excavating and disposing of contaminated soil in a secure location and replanting excavated areas.
- Dismantling and cleaning up the former Town of Uravan.

The wastes are contained on the Site; pollution of the San Miguel River is under control; and there is no longer any residential exposure to radiation from raffinates, raffinate crystals, and mill tailings containing uranium, thorium, and radium. On February 18, 2005, EPA deleted a portion of the Site from the NPL. This partial deletion pertains to 9.84 acres previously containing two historic structures, the Boarding House and the Community Center. On September 4, 2007, EPA deleted a portion of the Site on Colorado Department of Transportation (CDOT) Highway 141 (EPA 2015).

The Site is a Uranium Mill Tailings Radiation Control Act (UMTRCA) Title II site (U.S. Department of Energy [DOE] 2014). Congress enacted UMTRCA to provide for the disposal, long-term stabilization, and control of these mill tailings in a safe and environmentally sound manner and minimize or eliminate radiation health hazards to the public. UMTRCA established two programs (Title I and II) to protect the public and the environment from uranium mill tailings. The UMTRCA Title I program authorizes DOE to remediate "inactive" processing sites. Inactive processing sites are those that were no longer licensed under the Atomic Energy Act as of January 1, 1978. The UMTRCA Title II program is directed toward uranium mill sites licensed by the NRC or Agreement States on or after 1978. Title II of the Act provides:

- NRC authority to control radiological and non-radiological hazards
- EPA authority to set generally applicable standards for both radiological and non-radiological hazards
- Eventual state or federal ownership of the disposal sites under general license from NRC

Land transfer to DOE for long-term custody of the property is a statutory requirement for uranium mill tailings sites. The portions of the Site that require long-term care under the UMTRCA Title II program will transfer to DOE's Office of Legacy Management (LM) program along with a long-term care fee in accordance with Atomic Energy Act of 1954 (Public Law [P.L.] 83-703) – Section 83 (Ownership and Custody of Certain Byproduct Material and Disposal Sites) and Uranium Mill Tailings Radiation Control Act (P.L. 95-604), Title II (Uranium Mill Tailings Licensing and Regulation, Section 202, Custody of Disposal Site). The land requiring long-term care under UMTRCA is herein referred to as property within the "DOE transfer boundary." It is anticipated that areas not included in the DOE transfer boundary will be owned by either CDOT, Montrose County, or the U.S. Department of the Interior Bureau of Land Management (BLM). Details of the long-term program and future ownership are still in discussion with project stakeholders.

1.3 Report Organization

The RI report is organized into the following sections:

- **Section 1: Introduction** – Presents the purpose and objective of this RI report, Site location and description, and report organization.
- **Section 2: Site Physical Characteristics** – Presents a description of Site characteristics, including a brief description of climate, geology, hydrogeology and hydrology, and ecological setting. Demographics, land use, and ownership are also presented in this section.
- **Section 3: Remedial Action Objectives** – Provides a summary of general compliance with the remedial action objectives (RAOs) and applicable or relevant and appropriate requirements (ARARs).
- **Section 4: Previous Investigations and Remedial Actions** – Provides a summary of the previous investigations and remedial actions completed at the Site.

- **Section 5: Residual Impacts** – Provides a summary of any residual impacts.
- **Section 6 Findings and Recommendations** – Provides a summary of the findings regarding Site status.
- **Section 7: References** – Documents the references cited in this report.

The following appendices are included to provide additional information and summarize relevant data.

- **Appendix A:** Site-Specific Soil Cleanup Objectives
- **Appendix B:** Groundwater Alternative Concentration Limits Application Approval
- **Appendix C:** Alternative Soil Standards Application Approval
- **Appendix D:** Confirmation Report Radiation Survey and Sample Location Maps
- **Appendix E:** 2016 Annual Uravan Report
- **Appendix F:** Summary of Federal and State Applicable or Relevant and Appropriate Requirements and To Be Considered
- **Appendix G:** Review of Umetco Risk Assessment, Alternative Soils Standards, and Residual Contamination

Section 2
Site Physical Characteristics

This section provides an overview of the Site physical characteristics, including demographics, land use, and ownership, as well as climate, geology, and hydrogeologic information. For additional Site physical characteristics, refer to the CD/RAP (Umetco 2005).

2.1 Demographics, Land Use, and Ownership

Mining operations in this area of Colorado began in the early 1900s. Standard Chemical Company first acquired mining claims in the area and began mining radium bearing carnotite ore in approximately 1910. In 1912, the Standard Chemical Company built a radium mill, located on the valley floor along the San Miguel River at the site of what later became known as "A-Plant." The mill produced radium until 1919, and from the 1930s to 1984 the plant operated as a uranium and vanadium processing facility. The RAP required all residents of the former Town of Uravan to vacate their residences by December 31, 1986. The former Town of Uravan was established to house workers and their families at the mill and mine facilities. The RAP stated that Union Carbide Corporation (UCC)/Umetco was not to permit any building or improvement at the Site to be constructed or occupied as a residence.

2.1.1 Current Ownership and Land Use

Based on online cadastral mapping provided by Montrose County as well as Figure 2-1 (revised May 12, 2015), most parcels within the Site are currently owned by Umetco with a few exceptions (i.e., portions of Windblown Areas E and J [BLM ownership], the Upper and Lower Burbank Quarry [DOE ownership], and ancillary BLM withdrawal areas). The Nature Conservancy Visitor's Site was deeded to the State of Colorado under ownership of the Nature Conservancy. The Town Area, the Ball Park and a portion of Homer Woods is currently under Montrose County ownership. There are also CDOT Highway 141 as well as County Roads EE-22 and Y-11 within the Site. As mentioned in Section 1.2, two areas of the Site have been previously deleted from the NPL (EPA 2015), and CDOT Highway 141 is one of the deleted areas.

Umetco performs an annual survey of land use within 5 miles of the Site and reports findings annually pursuant to Radioactive Materials License No. 660-02, Amendment 14. Recreational activities in the area include, but are not limited to, hunting, fishing, camping, and rafting on the San Miguel River.

Limited mine reclamation and exploration drilling activities were observed from 2010 to 2014. No mining or drilling activities were observed within the 5-mile radius of the site during 2016. However, survey markers were restaked at a mine claim on the Dolores Bench. Only the Spring Creek Mesa Mine spoil piles have the potential to impact reclamation activities within the 5-mile radius of the Site.

Cattle, although not dairy cattle, graze during the spring and fall. There are no gardens or fruit trees in restricted areas of the Site. (Umetco 2017).

Within approximately a 10-mile radius of the Site, there are nine completed wells for domestic, municipal, or stock use.

- Five domestic wells owned by UCC with one on-site well and four off-site wells; the closest off-site well is approximately 6 miles away.
- One municipal well owned by UCC is approximately 3.80 miles away from the site.
- Three privately-owned stock wells with the closest well approximately 2.75 miles away.

Umetco has and will continue to maintain existing water rights in the San Miguel River (in trust) and the F-Block Well (for construction water). No new water rights were filed during 2016.

2.1.2 Reasonably Likely Future Ownership and Land Use

Future ownership has not yet been finalized; however, Umetco proposes to transfer ownership of land to various entities, including DOE, Montrose County, and BLM. Figure 2-1, is the land status map that indicates the proposed land transfer boundaries. Within these transfer boundaries, various county and state roads have easements to ensure long-term operations and maintenance.

For proposed transfer from Umetco to DOE, the primary areas are:

- Atkinson Creek Disposal Area
- Club Ranch Ponds Area
- River Ponds Area
- Tailings Piles Area
- Club Mesa Area
- Town Dump
- Mill Areas, including A-Plant and B-Plant (and Repository)
- Portions of the former Town of Uravan and Adjacent Areas

For proposed transfer from Umetco to Montrose County, the primary areas are:

- Portions of the former Town of Uravan and Adjacent Areas and part of Homer Woods.

For proposed transfer from Umetco to BLM, the primary areas are:

- Upper Club Mesa Borrow Areas
- Portions of the A-Plant, the Gym Area, and the Water Storage Ponds
- Miscellaneous Mining Claim Areas West of the Site

The future land use and proposed ownership within each of the transferred Site boundaries is still under consideration between Umetco, CDPHE, DOE, EPA, Montrose County, and BLM.

2.2 Climate

The annual mean temperature during the period of record (1960 through 2014) was 53.2°F (11.8°C). The annual mean maximum temperature at Uravan was 69.1°F (20.6°C) and the annual mean minimum was 37.3°F (2.90°C). Extreme temperatures recorded at Uravan during the period of record show a minimum of -14.6°F (-23.3°C) which occurred in January 1971 and a record maximum of 110.7°F (41.1°C) which occurred in July 1989 (Colorado Climate Center [CCC] 2015).

The annual average total precipitation received at Uravan from 1960 through 2014 was 12.5 inches (31.8 centimeters [cm]). An annual maximum of 21.4 inches (54.4 cm) of precipitation was recorded in 1965, and an annual minimum of 7.1 inches (18.0 cm) was recorded in 1989. The maximum monthly precipitation recorded at Uravan was observed in October 1972 when 5.9 inches (14.9 cm) of precipitation was recorded, and the minimum monthly precipitation has been 0.0 inches for several months during various years. During the period of record, the greatest single daily precipitation amount was 1.9 inches (4.8 cm), occurring on July 24, 1971 (CCC 2015).

Winds at Uravan are strongly influenced by the San Miguel River Valley. The highest frequency wind directions generally parallel the river valley and are from the southeast. Winds from this general quadrant were observed 59 percent of the time during the period of record. These winds represent the drainage flow of air that occurs generally during the night and early morning hours. Winds flowing up the river valley from the northwest were observed 24.9 percent of the time. These winds generally occur during the late morning and afternoon or after a frontal passage. The annual mean wind speed is approximately 4.4 miles per hour (1.95 meters/second).

Studies in the Uravan area have shown the net potential evaporation rate for the entire year to be approximately two gallons per minute per acre or approximately 36 inches per year (91 cm/year) (Umetco 2005).

Severe weather in the area is usually in the form of intense rainfall or hail, both resulting from thunderstorms. The 10-year storm is estimated to be 1.3 to 1.5 inches of rainfall within 6 hours and the 100-year storm consists of 2.9 to 3.3 inches of rainfall within 24 hours. The thunderstorm season occurs during late spring and summer. Strong winds and hailstorms may accompany thunderstorm activity (Umetco 2005).

2.3 Geology

Near-surface formations in the Uravan area are primarily Mesozoic-era sandstones, shales, and conglomerates. The general stratigraphy, structure, seismicity, fault activity, and geomorphology are provided in the subsections below.

2.3.1 Stratigraphy

About 18,400 feet of relatively flat-lying Paleozoic and Mesozoic-age sedimentary rocks underlie the Uravan area. A stratigraphic column of the formations present at Uravan is shown on Figure 2-2. This sedimentary section consists of about 1,700 feet of Mesozoic rock, which is primarily comprised of sandstone, mudstone and shale of continental origins. The Mesozoic rocks are underlain by about 16,700 feet of Paleozoic rocks consisting of non-marine sandstones and marine carbonates, evaporites, and shales. This thick sedimentary section rests on Precambrian-age crystalline rocks.

Surficial deposits are usually thin and primarily colluvial, residual, and eolian deposits interspersed with bedrock outcrops along the canyon sides and on the mesa tops. Stream alluvium and small alluvial fans are present along the San Miguel River and its principal tributaries. Modern floodplain deposits are limited. In the Uravan area, these deposits are present upstream of the former town. Downstream of the former town for several miles, the San Miguel has incised a narrow canyon into the Kayenta Formation and underlying Wingate Sandstone and Chinle Formation. At Uravan, there is evidence of three former floodplain levels as indicated by thin terrace gravels. The three former floodplains lie about 10, 25, and 60 feet above the present incised river channel. These floodplain surfaces have been modified considerably by subsequent colluvial deposition from the adjacent canyon sides (Umetco 2005).

2.3.2 Structure

Uravan is located on the southwest limb of the northwest trending Nucla Syncline. This syncline is a relatively simple structure downwarp, which lies between the structurally more complex Uncompahgre Uplift and the Paradox Valley Anticline. The Mesozoic strata at Uravan are gently inclined at about 2° toward the northeast. Folding of these major structural elements may have occurred during the late Cretaceous or Eocene Laramide orogeny, about 40 to 70 million years ago.

Faults with large displacements in the Mesozoic sedimentary rock are not present in the Nucla Syncline and major faults have not been recognized at the existing tailings or mill effluent disposal sites. Northwest-trending faults which may have been active in the Quaternary are present along the western flank of the Uncompahgre Uplift. Several northwest-trending normal faults which displace Quaternary deposits are present along the collapsed crest of the Paradox Valley Anticline (Umetco 2005).

2.3.3 Seismicity

The Uravan region is in an area that has experienced a relatively low level of seismic activity for about the last 125 years. The more frequent and larger earthquakes in the region have occurred in the intermountain seismic zone which generally coincides with the Wasatch Mountain range in Utah. This zone of major seismic activity is located about 170 miles to the west of Uravan. Because of its distance from the Site, the intermountain seismic zone will not have a major impact at Uravan. The historic seismicity from this zone probably has not caused site intensities at Uravan greater than IV and peak bedrock accelerations likely have not exceeded 0.02g (Umetco 2005).

2.3.4 Active Faults

Studies indicate there are several faults in the region that are suspected to be active faults. The locations of these faults are shown on Figure 2-3. Historic earthquake activity has not been associated with any of these faults, but geologic conditions indicate fault movement may have occurred as recently as the Quaternary, within the last 1.8 million years. The suspected active faults are located either along the flanks of the Uncompahgre Uplift or along the flanks of the collapsed Paradox Valley Anticline and other salt anticlines to the southwest. The Paradox Valley Faults and other salt anticline faults are suspected to be actively moving at the present. However, because their movement is caused by salt flowage, they are not considered by researchers to be capable of generating moderate to large earthquakes.

The other potentially active faults northeast of Uravan are along the southwestern or northeastern flank of the Uncompahgre Uplift. Detailed studies of the Uncompahgre faults would be required to establish if they have moved recently enough to be classified as capable faults in accordance with Nuclear Regulatory Commission criteria. Since such studies have not been made, these faults were assumed to be capable faults and therefore considered in assessing the seismic risk at Uravan (Umetco 2005).

2.3.5 Geomorphic Processes

Geomorphic features along the Colorado River and its principal tributaries in the Colorado Plateau, such as the San Miguel and Dolores Rivers, indicate the Colorado River system has been downcutting during at least the last 10 million years. Long-term average rates of river incision, from a variety of localities within the Colorado Plateau, range from 0.005 feet per thousand years to 1.4 feet per thousand years and average about 0.5 feet per thousand years. Canyon widening has also accompanied river downcutting during this period. Canyon widening primarily results from mesa rim retreat and mass wasting along the mesa flanks. Mesa tops are formed by resistant sandstone units and remain relatively unchanged during erosional processes. Slow erosion, primarily by mass wasting of the underlying weaker rock units, results in slow retreat of the rims. Although the regional geomorphology indicates river downcutting and mesa rim retreat have been the predominant geomorphic processes, several episodes of river aggradation associated with Quaternary glacial periods have also occurred.

The past geomorphic processes of river downcutting and aggradation, along with canyon widening, have shaped the present landscape and these processes are expected to continue. Future long-term geomorphic rates are expected to be similar to those in the past. Since parts of the long-term repositories are on Club Mesa, which is about 400 to 700 feet above the San Miguel River, long-term impacts were assessed. The resistant sandstone cliffs which make up the mesa rims are actively retreating. Maximum rate for rim retreat adjacent to the San Miguel River is estimated to be about 1.0 to 4.0 feet per thousand years. Retreat rates for the mesa rims adjacent to tributary drainages range from 0.4 to 4.0 feet per thousand years (Umetco 2005).

2.4 Hydrogeology

Aquifers in the Uravan area are generally limited to the hydrostratigraphic units that have sufficient permeability to transmit groundwater. These sandstone units generally have variable permeabilities due to grain size, fracturing, sorting and secondary cementing. Groundwater in the region is transmitted via secondary (joint) permeability and primary (intergranular) permeability. Secondary permeability in the region tends to be directional and highly variable. Mesozoic Formations capable of transmitting water in economic amounts include the Dakota and Burro Canyon Formations, the Salt Wash member of the Morrison Formation, and the Entrada, Kayenta, and Wingate Sandstones (Figure 2-2). Mesozoic strata that are not capable of transmitting water in economic amounts and are therefore considered aquitards, include the Brushy Basin member of the Morrison Formation and the Summerville, Chinle, and Moenkopi formations (Figure 2-2).

The Chinle Formation, which underlies the Kayenta-Wingate aquifer, is the first hydrogeologic unit of concern in the Uravan area. All geologic units below this aquitard, which underlies the deepest water-bearing zone of concern, should not be impacted by the migration of contaminated

liquids. A description of the Chinle Formation and the hydrogeologic units above this formation follows.

2.4.1 Chinle Formation

The Chinle Formation is about 400 feet thick and consists predominantly of soft red siltstone. The Chinle does not produce water in the Grand Junction area and most likely will not produce water in the Uravan area. Because of its lithology, the permeability is probably very low, and it likely acts as an aquitard. The upper part of the Chinle in the Uravan area contains sandstones of low permeability and probably is in hydraulic connection with the overlying Wingate sandstones (Umetco 2005).

2.4.2 Wingate Sandstone

The Wingate Sandstone is about 200 feet thick in the Uravan area and is composed of very fine to fine grained sand with minor interstitial clay and calcite cement. Portions of the Wingate are water-bearing in the region, despite its relatively low permeability. The aquifer can produce up to 500 gallons per minute and well yields of over 100 gallons per minute are common. These high yields are probably due to high fracture permeability, rather than primary permeability of the formation. However, studies indicate the Wingate at Uravan is predominantly unfractured and of low permeability.

Regionally, Wingate groundwater is sodium bicarbonate water of relatively good quality, similar to that of the Entrada Sandstone. In the past, this groundwater has been used as the Uravan water supply. In the Uravan vicinity, recharge to the Wingate Sandstone probably occurs in two primary areas: (1) west of Uravan along the Dolores River and the flanks of the Paradox Valley, and (2) northeast of Uravan along its exposed margin, bordering the Uncompahgre Uplift. Recharge occurs from both direct infiltration to Wingate outcrops and from vertical infiltration from overlying units. The Wingate is not exposed in the immediate area around Uravan, so discharge is either northwest along the trend of the synclinal axis (near the confluence of the San Miguel and Dolores Rivers) or upward into the Kayenta through connecting fractures (Umetco 2005).

2.4.3 Kayenta Formation

The Kayenta Formation is approximately 180 to 200 feet thick in the Uravan area. The formation consists of lenticular to irregularity-bedded layers of fine to medium-grained sandstone, irregular lenses of siltstone and shale, and a few lenses of conglomerate or conglomeratic sandstone. The sandstones are generally harder and coarser grained then the underlying Wingate, particularly the lower beds of the Kayenta.

Regionally, the Kayenta is not considered to be an aquifer. Locally, the Kayenta contains water and is hydrologically connected with the underlying Wingate and overlying Navajo and Entrada formations. Permeabilities are generally very low, but in the Uravan area laboratory values of horizontal and vertical permeabilities are 740 and 690 feet per year, respectively, for an upper sandstone.

Also, a porosity of 26.9 percent has been reported. Recharge probably occurs along the flanks of the Dolores River and Paradox Valley, west of Uravan, where the Kayenta is exposed. Northeast of Uravan, recharge also may occur along the exposed edge of the Kayenta on the margins of the

Uncompahgre Uplift. Flow is probably towards the San Miguel River Canyon where the Kayenta is at its lowest exposed elevation. Therefore, flow is generally toward the San Miguel from both the northeast and southwest (Umetco 2005).

2.4.4 Navajo Formation

The Navajo formation in the Uravan area is an outlier of the main formation body which lies further to the west. The Navajo is 30 feet thick or less in this area and is composed of massive, fine-grained, very well-sorted, clean, nearly white sandstone. Because the areal extent of the Navajo in the vicinity of Uravan is small, groundwater information is not available; however, it is thought to allow vertical hydraulic connection between water-bearing zones above and below it (Umetco 2005).

2.4.5 Entrada Formation

The Entrada Formation is 80 to 110 feet thick in the Uravan area and is predominantly a fine to very-fine grained sandstone with small amounts of medium-grained sand and from less than 10 percent to as high as 30 percent silt. Some beds, particularly those near the base, contain a small proportion of well-rounded, frosted and iron-stained, coarse-grained sand.

Regionally, the Entrada is considered the most productive of the various bedrock water-bearing zones. Locally, however, the Entrada may be relatively dry due to dissection by various canyons. Flow tests made on the Entrada wells have yielded transmissivity values of 150 gallons per day per foot (gpd/ft) and storativity of 5×10^{-5}.

Water quality tends to be good and the water is a sodium bicarbonate type that becomes increasingly soft at greater distances from the recharge area due to natural base exchange. Recharge probably occurs west and southwest of Uravan where the Entrada is exposed and northeast along the flanks of the Uncompahgre Uplift. Discharge probably occurs along the San Miguel River and in Hieroglyphic Canyon (Umetco 2005).

2.4.6 Summerville Formation

The thinly bedded Summerville Formation consists mainly of alternating beds of siltstone and sandstone with shale and mudstone near the top. In the Uravan vicinity, the Summerville is 40- to 60-feet thick and considered an aquitard in this region. This formation generally does not yield water to wells, due to its low permeability. The Summerville Formation effectively confines water in the Entrada and lower units; however, the Summerville Formation is not an aquiclude (Umetco 2005).

2.4.7 Morrison Formation

The Morrison Formation in the Uravan Area consists of the Salt Wash Member and the Brushy Basin Member. The lithology and hydrogeological properties of each member are listed in the subsections below.

2.4.7.1 Salt Wash Member

The Salt Wash Member of the Morrison Formation ranges in thickness from 0 to 300 feet in this area and is comprised of alternating beds or lenses of siltstone or mudstone and highly lenticular

sandstone, and near the base, a few thin limestone beds. The sandstone beds, which are the dominant lithology, consist mostly of fine, medium, and coarse grained quartz sand.

Because of the lithology and lenticular nature of the Salt Wash Member, permeabilities tend to be relatively low and water availability highly variable. Flow tests on wells in the region completed in the Salt Wash yield a transmissivity and storativity of 47 gpd/ft and 3 x 10^{-5}, respectively.

Salt Wash groundwater tends to be sodium bicarbonate-sodium sulfate water of relatively good quality. Pyrite is suspected as the source of the sulfate. High sodium levels suggest water in the Salt Wash has undergone more natural base exchange than water in any of the other water-bearing units.

The Salt Wash Member is exposed over a wide area southwest of Uravan and is probably one area of recharge. As are the other formations, this member is also exposed along the flanks of the Uncompahgre Uplift and receives water at that location. The San Miguel River Canyon and Atkinson Creek are areas of natural discharge (Umetco 2005).

2.4.7.2 Brushy Basin Member

The Brushy Basin Member of the Morrison Formation is about 400 feet thick and composed dominantly of variegated mudstone with lesser amounts of sandstone, conglomeratic sandstone, and limestone. This unit is considered to be an aquitard for the underlying water-bearing zone in the Salt Wash Member. Packer tests in the upper part of the Brushy Basin on Spring Creek Mesa showed permeabilities ranging from 0.62 to less than 0.01 foot/year. Very small yields have been reported from wells completed in sandstone layers in this unit, but water availability is highly variable and for the most part poor to nonexistent (Umetco 2005).

2.4.8 Burro Canyon Formation

The Burro Canyon Formation is up to 200 feet thick in this area and is composed of as much as 85 percent sandstone with individual sandstone beds up to 100 feet thick. Green shale or siltstone, red or purple shale, and locally, thin gray nodular limestone is also present in the formation.

Because the sandstones of the Burro Canyon are generally lenticular and tightly cemented, intergranular permeability is very low. However, locally, fracture permeability may provide fresh water to wells. Aquifer tests on well SCM-1 on Spring Creek Mesa showed a permeability of 827 feet/year.

South of the San Miguel River on Club Mesa, the Burro Canyon exists as isolated erosional remnants, whereas north of the river it caps much of the area. The erosional remnants are most likely unsaturated. North of the river on Spring Creek Mesa, the lowest portion of the formation is saturated. Recharge occurs along the flank of the Uncompahgre Uplift, exposed areas on the mesa tops, and possibly through the overlying Dakota Sandstone. Discharge is through the walls of the various canyons which dissect the mesas and possibly by vertical leakage.

Water quality in the Burro Canyon Formation on Spring Creek Mesa is somewhat variable. For example, total dissolved solids (TDS) measured in various monitoring wells on Spring Creek Mesa show a TDS range from 640 to 3,500 milligrams per liter (mg/L) (Umetco 2005).

2.4.9 Dakota Sandstone

The Dakota Sandstone is up to 150 feet thick in the Uravan area and is composed of fine to medium-grained sandstone that ranges from non-cemented to well-cemented.

Interbedded with the sandstone are carbonaceous shales and low-grade coals, and mudstone. In the Uravan area, the Dakota may be water-bearing only locally. Generally, the erosional remnants of the Dakota in the Uravan area are unsaturated, but may allow recharge to the Burro Canyon (Umetco 2005).

2.5 Hydrology

The following sections provide a general overview of the Site hydrology.

2.5.1 General

The San Miguel River provides the primary drainage of the project area. Headwaters of the San Miguel originate in the San Juan Mountains from which the river flows northwest to its confluence with the Dolores River, about 4 miles downstream from Uravan. The San Miguel is perennial with pronounced seasonal fluctuations exhibited by its hydrograph. This streamflow pattern is characteristic of rivers whose flow is derived primarily from snowmelt runoff. Peak discharges on the San Miguel generally occur in late spring or early summer. The San Miguel exhibits a seasonal flow pattern typical of streams in the region. Major flows occur from May to late June with moderate peaks, large volumes, and long flow durations. Average flow is 345 cubic feet per second (cfs) with a range of 12 to 6,690 cfs. The San Miguel flows are influenced by upstream diversions, storage and irrigation.

Principal tributaries to the San Miguel River in the vicinity of Uravan include Spring, Atkinson, Tabeguache, and Hieroglyphic Creeks. All are intermittent streams that peak following rainfall events. Peak flows occur most frequently in spring and summer. Flows are generally low in fall and winter and may reach zero flow (Umetco 2005).

2.5.2 Flood Forecast

A flood study for the Site was conducted in 1982. This study did not include an analysis of flood erosion mechanisms such as bank erosion rates during floods. The study encompassed the stretch of river upstream of Hieroglyphic Canyon to downstream of Atkinson Creek. The 10-, 50-, 100-, and 500-year frequency floods were calculated using the Army Corps of Engineers HEC-2 model.

The 500-year frequency flood would reach the former level of the River Ponds. This flood would not overtop the former Club Ranch Ponds area, or Atkinson Creek Disposal area, or impact the former A-Plant mill area. The River Ponds area would not be overtopped by the 100-year frequency flood (Umetco 2005).

2.5.3 Surface Water Chemistry

The San Miguel River water quality changes significantly as it flows from the Telluride valley to the mouth below Uravan. The seasonal water quality varies in response to snowmelt and storms, as well as to natural and mining loadings at various locations within the watershed. Best water quality for major ions is observed during spring runoff while fall and winter baseflow periods show increased concentrations of contaminants.

Historical data (1969-1981) on the concentrations of major cations (calcium [Ca], magnesium [Mg], sodium [Na], potassium [K]) and anions (sulfate [SO_4] and chloride [Cl]) above and below Uravan illustrate the seasonal variability as well as the changes caused by the Uravan mill when it was in operation.

During January 1986, a network of river and stream stations was designed to identify the various natural and anthropogenic inputs to the San Miguel and Dolores Rivers. At each river station, water quality samples were taken in conjunction with samples of sediments and aquatic biota. Data collected during 1986 showed average concentrations relative to the 1969-1981 data set.

Significant chemical changes were noted in the study sections of the San Miguel River from Naturita to its confluence with the Dolores River. Data shows that there is a nearly continuous rise in conductivity. The dominant parameters for downstream station ASM01 and upstream station ASM06 were compared showing increases in Ca, Mg, K, Na, Cl, SO_4, ammonia (NH_3) and nitrate (NO_3) (Umetco 2005).

2.6 Ecological Setting

The following sections provide a general overview of the Site ecological setting.

2.6.1 Soils

Soils on the steep and extremely steep side slopes of the canyons are classified as the Rock outcrop-Torriorthents complex. Rock outcrop and Torriorthent components are intricately intermingled. Rock outcrop components consist of barren escarpments, ridge caps, and sandstone points. Torriorthent components may be shallow or deep and formed in residuum and colluvium derived from sandstone and shale. The surface layer is commonly light, bouldery clay loam. Permeability is moderately slow, available water capacity is moderate, runoff is very rapid, and hazard of water erosion is very high.

Bench areas are covered primarily by the very bouldery clay loams of the Bodot-Torriorthents complex. The Bodot soil composes 45 percent of the map unit, with 40 percent Torriorthents, 10 percent Rock outcrop, and 5 percent Pinon and Bowdish soils. The Bodot soil is moderately deep and formed in residuum derived dominantly from shale. The surface layer is very bouldery clay loam. Permeability is slow, water capacity is moderate, runoff is rapid to very rapid, and hazard of water erosion is slight to very high.

Soils on the mesa tops are composed primarily of a combination of Pinon-Bowdish-Rock outcrop complex and Barx-Progresso complex. Pinon soils are shallow and formed in residuum derived from sandstone and shale. The surface layer can be gravelly loam, gravelly sandy loam, sandy loam, or cobbly loam.

Permeability is moderate, available water capacity is very low, runoff is medium to very rapid, and hazard of water erosion is slight to very high.

Bowdish soils are moderately deep and derived from interbedded sandstone and shale. The surface layer may be sandy loam, sandy clay loam, gravelly sandy loam, or cobbly sandy loam. Permeability is moderate, available water capacity is low, runoff is medium to very rapid, and the hazard of water erosion is slight to very high.

The Barx soil is deep and formed in alluvium derived dominantly from sandstone. The surface layer is typically fine sandy loam. Permeability is moderate, available water capacity is high, runoff is medium to rapid and the hazard of water erosion is slight to very high. Barx soil composes 45 percent of the Barx-Progresso complex.

Forty percent of the Barx-Progresso complex consists of Progresso loam. The Progresso soil is moderately deep and formed in sandstone-derived alluvium. Permeability is moderate, available water capacity is moderate, runoff is medium to rapid, and the hazard of water erosion is slight to very high.

In the riparian zone, fluvaquents are the predominant soil type. These are deep, poorly drained soils that formed in stratified alluvium from mixed sources. The surface layer is commonly silt loam. Permeability is moderately rapid to very slow to medium, and the hazard of water erosion is slight to high (Umetco 2005).

2.6.2 Regional Vegetation

Vegetation in the area surrounding the Site is divided into three major community types: pinon-juniper woodland; sagebrush-grass community; and riparian zone. Small areas of mountain brush vegetation also occur where slopes are very steep and rocky. These vegetation types are described below.

2.6.2.1 Pinon-Juniper Woodland

This vegetation is a very widespread plant community type in the area around Uravan. It occurs on the canyon slopes, the mesa tops, and at higher elevations on the ridges than the sagebrush community. About 40 percent of the pinon-juniper woodland in this area occurs on moderate to steep slopes with sandstone outcrops. These steep slopes are areas of shallow soils and low productivity, producing 10 to 30 trees per acre. The other 60 percent of the pinon-juniper woodland occurs on gentler slopes with deeper soils. These stands are more productive with an average of 140 to 190 trees per acre.

The major canopy species in the pinon-juniper woodland are pinon pine (*Pinus edulis*) and two species of juniper (*Juniperus scopulorum* and *Juniperus osteosperma*). About 75 percent of the canopy is composed of junipers. Shrub species expected to be a part of the potential vegetation in this area include serviceberry (*Amelanchier utahensis),* four-wing saltbush (*Altriplex canescens*), snowberry (*Symphoricarpos oreophilus*), mountain mahogany (*Cercocarpus spp.*), bitterbrush (*Purshia tridentata*), cliffrose (*Cowania mexicana*), and Mormon tea (*Ephedra virdis*). Understory species are primarily grasses with a few forbs present (Umetco 2005).

2.6.2.2 Sage-Grass Community

This vegetation is found in canyon bottoms, on mesa tops, and on gentle, lower slopes of ridges. This vegetation generally occupies finer, deeper soils than the pinon-juniper woodland. It often occurs as open parks within pinon-juniper vegetation where the two vegetation types intergrade. Sagebrush forms about 10 percent of the plant cover. Perennial grasses and forbs form 50 percent and 5 percent of the plant cover, respectively. Big sagebrush (*Artemisia tridentata*), fringed sagebrush (*Artemisia frigida*), and winterfat (*Ceratoides lanata*) are the major shrub species (Umetco 2005).

2.6.2.3 Riparian Community

Riparian vegetation dominates in canyon bottoms near the San Miguel River Major. Species include tamarisk (*Tamarix pentandra*), narrowleaf cottonwood (*Populus angustifolia*), willows (*Salix spp.*), alder (Alnus tenuifolia), and birches (*Betula spp.*). The understory vegetation includes sedges (*Carex spp.*) and rushes (*Juncus spp.*) (Umetco 2005).

2.6.3 Threatened, Endangered, and Sensitive Species

Several threatened, endangered, and sensitive plant and animal species are found or have potential habitat in the area around Uravan. Endangered and sensitive plant species known to occur in the area are the Spineless Hedgehog Cactus (endangered), Paradox Lupine (sensitive), and Clove Phlox (sensitive). Endangered or threatened wildlife potentially in the vicinity of Uravan are the Peregrine Falcon, Bald Eagle, and the Black-footed Ferret.

Peregrine Falcons (*Peregrinus anatum*) may hunt waterfowl along the San Miguel River but more probably occur as migrants along the Dolores River where such prey as waterfowl, shore birds and passerine birds are more numerous. Sightings indicate an eyrie occurs in the area but its location is unknown. The Southern Bald Eagle (*Haliaeetus leucocephalus leucocephalus*) hunts fish and feeds upon carrion along the rivers of the Dolores River Basin. The Northern Bald Eagle (*Haliaeetus leucocephalus alascanus*) winters in the basin. The only difference between the subspecies seems to be that the Northern Bald Eagle is larger and heavier than the Southern Bald Eagle, but ranges in wing measurements and weights overlap. The Black-footed Ferret has not been definitely sighted in the Uravan vicinity, but its habitat is present (Umetco 2005).

Section 3
Remedial Action Objectives

A central component of EPA's remedial process under CERCLA is the development of preliminary RAOs and preliminary remediation goals (PRGs) for the response action that are protective of human health and the environment (40 Code of Federal Regulations [CFR] 300.430(e)).

The goal of the remedy selection process is "*to select remedies that are protective of human health and the environment, maintain protection over time, and minimize untreated waste*," according to the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR 300.430(a)(1)(I)). Preliminary RAOs are media-specific and source-specific goals achieved through completion of a remedial action that is protective of human health and the environment. These objectives are typically expressed in terms of the contaminant, the concentration of the contaminant, and the exposure route and receptor.

Preliminary RAOs are typically developed by evaluating several sources of information, including results of previous site investigations and potential ARARs. These inputs provide the basis for determination of whether protection of human health and the environment is achieved for a remedial approach. During development of the preliminary RAOs, other PRGs and preferences for site outcomes that have been expressed by stakeholders may be considered. Although these goals are not considered requirements pursuant to the NCP (40 CFR 300), they may serve to guide the process for developing the remedial approach.

PRGs are defined as the average concentration of a chemical in an exposure unit associated with a target risk level such that concentrations at or below the PRG do not pose an unacceptable risk. Numerical PRGs can be based on existing environmental standards or risk calculations, thus providing crucial targets for remedial alternatives to meet. Identification and selection of the PRGs are typically based on preliminary RAOs, the current and anticipated future land uses, and the potential ARARs. The PRGs are typically presented as chemical- and media-specific values that directly address the preliminary RAOs.

The following discussion presents the identification of potential ARARs, preliminary RAOs, and the PRGs for the Site. Potential ARARs are identified for the purpose of evaluating previously completed remedial actions at the Site in accordance with the CD/RAP (Umetco 2005). Final ARARs, RAOs, and remedial goals (RGs) will be set forth in the decision document (i.e., final ROD).

3.1 Identification of Potential ARARs

Section 121(d)(2) of the CERCLA, 42 United States Code (USC) § 9621(d)(2), certain provisions of the current NCP, 40 CFR Part 300 (1990), and guidance issued by the EPA require that remedial actions at CERCLA sites must at least attain ARARs unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site.

State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive standards that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site.

In addition to legally binding laws and regulations, many Federal and State environmental and public health programs also develop criteria, advisories, guidance, and proposed standards that are not legally binding, but that may provide useful information or recommended procedures. These materials are called To Be Considered (TBCs), are not potential ARARs but may be evaluated along with ARARs to set protective cleanup level targets.

These requirements (i.e. ARARs) are threshold standards any selected remedy must meet unless a waiver is granted.

The CD/RAP (Umetco 2005, Recitals Paragraph XXVIII – Compliance with Applicable Law) indicates the remedial action described in the RAP requires a level or standard of control for all hazardous substances or pollutants or contaminants that will attain all legally applicable or relevant and appropriate standards, requirements, criteria, or limitations, including standards, requirements, criteria and/or limitations. These ARARs and To Be Considered (TBCs) are summarized in Appendix F.

3.2 Remedial Action Objectives

In 1985, Umetco and the State of Colorado entered into a CD and associated RAP. The RAP, as amended, was considered at the time to be the functional equivalent of an EPA RI/FS and ROD. The United States District Court for the District of Colorado lodged the CD and RAP on February 12, 1987. Previously identified objectives of the RAP were to:

- Protect surface and groundwater resources.
- Stabilize and control the tailings and other waste materials.
- Minimize radon emissions from the tailings and waste repositories.
- Conduct soil cleanup in a safe and environmentally sound manner.

3.3 Preliminary Remedial Goals

PRGs are defined as the average concentration of a chemical in a specific media for an exposure unit that is associated with a target risk level such that concentrations at or below the PRG do not pose an unacceptable risk. The PRGs must be presented as chemical- and media-specific values that directly address the RAOs.

PRGs for response actions under CERCLA are developed based on site-specific risk-assessments, ARARs, and/or to-be-considered material. The determination of whether a requirement is applicable, or relevant and appropriate, is made on a site-specific basis. Under CERCLA, cleanup levels should generally achieve a level of risk within the 1E-06 to 1E-04 carcinogenic risk range based on the reasonable maximum exposure for an individual. The cleanup levels to be specified include exposures from all potential pathways, and through all media (e.g. soil, groundwater, surface water, air, structures, and biota). The PRG levels for identified contaminants of concern at this Site are presented in the following sections.

While PRGs are typically identified in an FS report, CERCLA remedial action has already been completed for this Site and no additional physical remediation is planned. Therefore, PRGs will be referred to as soil cleanup objectives and groundwater standards in this report.

3.3.1 Remedial Action Goals for Soil

Table 4.1.2-1 of the RAP established two criteria for contaminated soil removal. Criterion 1 required cleanup of areas of the Site to exposure rates (based on scintillometer investigations) of less than 20 microroentgens per hour (µR/hr). This criterion allowed for State approval of remedial alternatives with residual exposure rates between 20 and 30 µR/hr, based on a comparative assessment of alternatives (CDPHE 2015b). Criterion 2 established cleanup objectives for radionuclides and metals, which were later incorporated into the 1999 Soil Cleanup Methodology document (see Appendix A).

According to the RAP, as amended, PRGs for soil contaminants of concern (COCs) (radionuclides) were based on 40 CFR 192. Subpart D of 40 CFR 192 established radioactivity limits for uranium byproduct materials pursuant to Section 84 of the Atomic Energy Act of 1954, as amended. These standards were developed specifically for the cleanup of uranium mill tailings sites under Section 102(2)(1) of UMTRCA (Title 1 sites) and were developed to limit the risk from inhalation of radon decay products in houses built on land contaminated with tailings, and to limit gamma radiation exposure of people using contaminated land. The State of Colorado uses UMTRCA standards for uranium mill sites (6 Code of Colorado Regulations [CCR] 1007-1 Part 18). The concentration criterion for surface soil (0-15 cm below ground surface [bgs]) averaged over an area of 100 square meters (m^2) is a health-based standard for exposure to gamma radiation. The concentration criterion for subsurface soil (greater than 15 cm bgs) is not a health-based standard but was developed to allow the use of field measurements to locate and remediate discrete deposits of high activity tailings (typically 300-1,000 picocuries per gram [pCi/g]) in subsurface locations. These PRGs were designed to achieve toxic constituent concentrations which approximate levels that existed prior to operations at the Site. Nevertheless, the RAP notes that the as low as reasonably achievable principle applies to soil radium cleanup at the Site.

The following tiered approach (assessment categories) was used to develop soil PRGs (i.e., cleanup objectives) for the Site (Umetco 1999, Section 2).

- Category 1 - RAP Soil Criteria
- Category 2 - Risk-Based Soil Cleanup Objectives for Residential Land Use Scenarios
- Category 3 - Site-Specific Risk and Dose Based Objectives
- Category 4 - Alternative Concentration Objectives

These categories were developed to allow for the assessment of specific project areas on a constituent by constituent basis and ensure that cleanup activities were protective of human health given site-specific land uses and topographic constraints in the area. Category 1, 2, and 3 soil PRGs are presented in Exhibit 3-1.

Exhibit 3-1 Summary of Soil Cleanup Objectives

Parameter	Category 1 – RAP Objective	Category 2 – Risk-Based Objective (Residential)	Category 3 (Dose/Risk) – Recreational Visitor	Category 3 (Dose/Risk) – Monitoring Worker	Category 3 (Dose/Risk) – Rancher
Radium-226 (0-15 cm)	7.1 pCi/g	7.1 pCi/g	58 pCi/g	100 pCi/g	170 pCi/g
Radium-226 (15-30 cm)	17.1 pCi/g	17.1 pCi/g	58 pCi/g	100 pCi/g	170 pCi/g
Thorium-230 (0-15 cm)	7.1 pCi/g	14 pCi/g	58 pCi/g	100 pCi/g	170 pCi/g
Thorium-230 (15-30 cm)	17.1 pCi/g	43 pCi/g	58 pCi/g	100 pCi/g	170 pCi/g
Natural Uranium	8.4 mg/kg	220 mg/kg	5,600 mg/kg	31,000 mg/kg	3,800 mg/kg
Arsenic	21.4 mg/kg	21.4 mg/kg	Site-specific[1]	Site-specific[1]	Site-specific[1]
Cadmium	2.0 mg/kg	75 mg/kg	1,900 mg/kg	10,000 mg/kg	61,000 mg/kg
Lead	164 mg/kg	400 mg/kg	Site-specific[2]	1,500 mg/kg	1,500 mg/kg
Molybdenum	2.3 mg/kg	370 mg/kg	9,400 mg/kg	51,000 mg/kg	310,000 mg/kg
Nickel	25.1 mg/kg	1,400 mg/kg	34,000 mg/kg	180,000 mg/kg	EU[3]
Selenium	11.2 mg/kg	370 mg/kg	9,400 mg/kg	51,000 mg/kg	310,000 mg/kg
Vanadium	60.1 mg/kg	520 mg/kg	13,000 mg/kg	71,000 mg/kg	430,000 mg/kg
Zinc	422 mg/kg	22,000 mg/kg	560,000 mg/kg	EU[3]	EU[3]

Notes:

1 = To be determined on a site-specific basis evaluating lack of feasibility to implement a 10^{-6} risk-based criterion.

2 = Calculated using Integrated-Exposure Uptake Biokinetic Model (IEUBK) Method).

3 = Value exceeds unity (Risk-Based Concentration is greater than 106 parts per million).

mg/kg = milligrams per kilogram, pCi/g = picocuries per gram, EU = Exceeds Unity

Category 1 - RAP Soil Criteria

Category 1 soil cleanup objective values are site-specific background concentrations (i.e., the background mean concentration plus 3 times the standard deviation).

Category 2 - Risk-Based Soil Cleanup Objectives for Residential Land Use Scenarios

Category 2 soil cleanup objective values for metals/metalloids (except for arsenic) are risk-based values that would result in a cancer risk of 1E-06 for carcinogens or a non-cancer hazard index of 1 for non-carcinogens, assuming residential land-use. The cancer risk of 1E-06 is at the lower end of the EPA-acceptable target cancer risk range of 1E-06 to 1E-04, and is typically used to evaluate the need for remediation or mitigation at a site. For non-cancer hazards, EPA generally considers a target hazard index of one or less as acceptable. The Category 2 value for arsenic is the site-specific background value since exposure to levels below background result in a cancer risk greater than 1E-06 and clean up to levels below background is not warranted. Category 1 and Category 2 values for Ra-226 are equivalent to background plus the health–based criterion specified in Subpart B of 40 CFR Part 192 for residential land use scenarios (e.g., for surface soil the cleanup value is 7.1 pCi/g or background (2.1 pCi/g + health-based criterion 5 pCi/g). The Th-230 soil cleanup level represents the initial Th-230 concentration, which would decay to Ra-226 at 1,000 years. Meeting cleanup objectives based on residential land use may indicate that additional remedial components are not warranted. However, Category 2 values do not account for soil-to-groundwater or soil-to-surface water transport pathways and are based on the assumption that groundwater use will be prohibited.

Category 3 - Site-Specific Risk and Dose Based Objectives

Category 3 values are dose- and risk- based soil cleanup levels derived for recreational receptors, monitoring workers, and ranchers based on site-specific exposure assumptions. Category 3 risk-based values for metals were based on a non-carcinogenic hazard index of 1; Category 3 values for arsenic, a carcinogen, were not developed. The only bioaccumulative exposure pathway included in Category 3 values was beef ingestion in the rancher exposure scenario. Doses for individual radionuclides correspond to an annual dose of 25 mrem/year. Acceptable doses were estimated so that the cumulative dose for site-related exposure was less than 100 mrem/year, which is the total acceptable effective dose established by EPA for members of the public exclusive of background radiation or medical administration.

Category 4 - Alternative Concentration Objectives

Alternative site-specific standards (Category 4) may be established under Subpart C of 40 CFR Part 192 under some special circumstances that allow the selection of remedial actions that come as close as reasonably achievable to meeting UMTRCA standards. Circumstances in which alternative standards may be considered include: situations in which worker safety would be adversely impacted, or clearly greater environmental harm would result from remedial action necessary to attain the standards; and for situations in which the materials do not pose a clear or present or future hazard and improvements could be achieved only at an unreasonably high cost. If alternative standards (also referred to as supplemental standards) are used, additional remedial components are generally included as a component of cleanup alternatives to ensure the response will be protective over time. For areas where cleanup-up values could not be achieved for various reasons (e.g., environmental hazards such as steep slopes, excessive costs in relationship to risk reduction) alternate soil standards (Category 4) were developed or proposed. Since there were no remediation areas at the Site where residual contamination exceeded any Category 3 criteria, the Category 4 risk assessments weren't necessary.

The rationale for each area for which alternative site-specific standards were developed is discussed in Sections 4 and 5 and summarized in Section 6.

3.3.2 Remedial Action Goals for Groundwater

3.3.2.1 Remedial Action Goals for Groundwater

According to the RAP, cleanup levels for groundwater COCs were based on 40 CFR 192.32(a)(2). In 2001, the RAP was updated and 12 contaminants were removed from the list of groundwater COCs. CDPHE updated the RAP again in 2005, reducing the list of groundwater COCs further to include cadmium, fluoride, nickel, selenium, uranium (natural), vanadium, zinc, Ra226 and gross alpha. As shown in Exhibit 2-2, current groundwater protection standards for cadmium and selenium have become more stringent since the 2005 RAP Amendment. However, the more stringent standards do not affect current protectiveness. Groundwater is not currently in use at the Site. The groundwater discharges to the San Miguel River (EPA 2015).

In 2003, CDPHE approved a groundwater Alternate Concentration Limit (ACL) application for 11 contaminants at the Site. The ACLs were based on protection of surface water quality in the San Miguel River and are also shown in Exhibit 2-2.

Monitoring of groundwater to confirm that State ACLs are protective of human health and the environment is ongoing (Umetco 2017).

Exhibit 3-2 Summary of Cleanup Goals, Amended RAP Cleanup Goals, and State ACLs for Groundwater COCs

Contaminant of Concern	1987 RAP Cleanup Goal (mg/L)	2005 Amended RAP Cleanup Goal (mg/L)	2003 State Alternate Concentration Limit (mg/L)
Aluminum	None	None	7.9
Ammonium	None	None	6,900
Antimony	Background	None	None
Arsenic	0.05	None	None
Barium	1.0	None	None
Beryllium	Background	None	None
Cadmium	0.01	0.05	0.26
Chromium	0.05	None	None
Cyanide	Background	None	None
Fluoride	Background	4.0	None
Iron	None	None	130
Lead	0.05	None	None
Manganese	None	None	130
Mercury	0.002	None	None
Molybdenum	0.05 (during period of RAP activities), 0.01, SDWA MCL, or Background, whichever is higher (after conclusion of RAP activities)	See Notes	None
Natural Uranium	0.03 (During Period of RAP activities), 0.015, SDWA MCL, or Background, whichever is higher (after conclusion of RAP activities)	0.044	5.5
Nickel	Background	Background	21
Nitrate + Nitrite (as N)	None	None	1,360
Selenium	0.01	0.05	0.5
Silver	0.05	None	None
Sulfate	None	None	32,600
Thallium	Background	None	None
Thorium-230	None	None	8,200 pCi/L
Vanadium	Background	Background	None
Zinc	Background	5.0	None
Radium-226 + Radium-228	Background	5 pCi/L	None
Gross Alpha	Background	15 pCi/L	None

Note:

Background methodology for dissolved constituents pursuant to Addendum A of the RAP, and as amended. Exhibit referenced and modified from the five-year review report (EPA 2015). Values for molybdenum and natural uranium were revised to reflect the most recent version of 5 CCR 1002-41. The molybdenum standard in 2012 was changed to 0.21 mg/L.

pCi/L = picocuries per liter, mg/L = milligrams per liter, SDWA = Safe Drinking Water Act,

MCL = Maximum Contaminant Limits, RAP = Remedial Action Plan

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Section 4

Previous Investigations and Remedial Actions

Under the CD, Umetco was required to complete reclamation activities specified in the RAP, as amended. To complete these activities, Umetco prepared construction, health and safety and environmental documents. Umetco submitted the documents to the CDPHE for review and approval. As remedial activities progressed, Umetco and CDPHE periodically modified and approved these documents to reflect changing Site conditions. These documents formed the basis for conducting, monitoring and assessing the remedial activities and determining if the selected remedy is protective of human health and the environment. The following general remedial activities as specified in the RAP, as amended, were required.

- Determine the extent of dispersed contamination and clean up areas found to be contaminated to applicable criteria for approximately 400 acres.
- Relocate more than 3 million cubic yards of mill wastes and contaminated materials to secure repositories on Club Mesa.
- Construct waste and tailing repository covers, liquid evaporation and retention ponds and permanent runoff control structures, utilizing more than 1.7 million cubic yards of earthen materials.
- Construct five double-lined ponds (totaling 40 acres) for the evaporation of hillside seepage, tailing pile seepage and extracted groundwater.
- Construct and utilize a new repository in the "B-Plant" area capable of disposing in excess of 1.8 million cubic yards of evaporative pond demolition debris and radioactive waste.
- Demolish and remove about 50 major mill facility structures and buildings, including the process systems and circuits, and remove over 260 buildings in the former Town of Uravan.
- Collect over 70 million gallons of hillside and tailing seepage, containing approximately 6,000 tons of contaminated inorganic compounds. Hillside and tailing seepage that was collected was transferred to Club Ranch Ponds for management by evaporation.
- Extract approximately 245 million gallons of contaminated liquids from the groundwater with the removal of approximately 14,500 tons of contaminated inorganic compounds. Contaminated groundwater that was collected was transferred to Club Ranch Ponds for management by evaporation.
- Remove contaminated materials from the Old and New Town Dumps with placement into the Club Mesa Tailing repository.

An area-by-area summary of conditions, RAP requirements, remedial actions conducted and contamination remaining, if any, are described in the sections below for the nine solids areas and five liquids remedial activities described in the RAP.

4.1 Solids

The RAP, as amended, described remedial activities for solids (primarily contaminated soils, mill tailings, and raffinate crystals) in nine different areas.

- Atkinson Creek Disposal Area
- Club Ranch Ponds Area
- River Ponds Area
- Tailings Piles
- Club Mesa Area
- Mill Areas
- Town and Adjacent Areas
- Burbank Quarry
- Borrow Areas on Club Mesa

The following sections describe previous investigation and remedial action for each solids area. Figure 2-2 shows the location of each solids area relative to the Site.

4.1.1 Atkinson Creek Disposal Area

The Atkinson Creek Crystal Disposal Area was located downstream from the Club Ranch Ponds and adjacent to Atkinson Creek. UCC constructed this disposal area in the early 1970s on the site of a former mobile home park. UCC removed the mobile homes and the underlying soils were excavated and stockpiled adjacent to the area. After preparation of the site, UCC removed an estimated 200,000 cubic yards of raffinate crystals from Club Ranch Ponds #1 and #6 and stored them in the Atkinson Creek area. No liner was placed beneath the crystals to prevent contamination of the underlying soils or groundwater. UCC placed natural soils on the raffinate crystals to form a soil cover approximately 12-inches thick (E2 Inc. [E2] 2010). The RAP specified the following remedial activities for the Atkinson Creek Crystal Disposal Area.

- Remove raffinate crystals and cover soils from the Atkinson Creek Crystal Disposal Area and place the materials in the Burbank Quarry secure crystal repository.
- Remove peripheral contaminated soils and contaminated soils beneath the crystals in accordance with Table 4.1.2-1 of the RAP, or until bedrock or the water table is encountered. The peripheral contaminated soil was to be disposed of on the Club Mesa tailings piles.
- Put runoff controls in place during remedial activities.
- Following removals, grade the ground surface to a stable configuration, cover with at least 1 foot of random fill, and vegetate.

Major removal activities began at the Site in 1991 following construction of runoff and drainage controls. Approximately 110,000 cubic yards of raffinate crystals (including the crystals, cover soils, and minimum 1 foot of contaminated soil from under the crystals) were removed from January to June 1991 (Umetco 1994a).

Following the initial removal, Umetco performed a walking scintillometer scan of the work area. All readings were below the 20 µR/h standard for no further action established on Table 4.1.2-1 of the RAP. However, confirmatory laboratory soil sample results revealed RAP cleanup objective exceedances at 18 locations (all 18 locations for Thorium-230, three for Uranium-nat, one for molybdenum, and one for vanadium) (Umetco 1994a). Umetco removed an additional 3,000 cubic yards of soil in the exceedance areas and resampled the locations.

Based on the resampling results, residual RAP cleanup objective exceedances of thorium-230, molybdenum, vanadium, and arsenic remained at the Atkinson Creek Crystal Disposal Area. Umetco conducted a risk assessment of the residual contamination and developed proposed appropriate remediation levels (ARLs) for these constituents based on the addition of one foot of clean soil cover. Umetco concluded that although arsenic concentrations remained above ARLs, the resultant concentrations did not pose a significant incremental risk above that associated with background concentrations (Umetco 1994a).

Umetco submitted revisions to the risk assessment report in November 1994, based on CDPHE comments set forth in a letter dated June 14, 1994. (Umetco 1994b). The revisions included an updated ARL for Molybdenum of 4,200 mg/kg for soil exposure (assuming the 1-foot cover is in place). The revised report also included an assessment of the longevity of the one-foot soil cover. The soil cover was estimated to last between 1,700 and 5,000 years in different portions of the excavation area.

Post-excavation activities, including removal of runoff controls, removal of the wheel wash system, grading with 1 foot of random fill and reseeding, were completed in December 1993 and were documented in Compliance Report CR-400-4.

Umetco performed radiological surveys for exposure rates and surface soil radium-226 in December 2001, as documented in compliance report CR-400-5. An average exposure rate of 13.6 µR/h with a maximum exposure reading of 58.0 µR/h was noted (average exposure in the grid with the maximum reading was 20 µR/h). Radium-226 concentrations averaged 3.4 pCi/g with a maximum grid average of 106.4 pCi/g. The grid with the maximum reading had a reading average of 13 pCi/g. Two grids had reading averages over 7 and less than 17 pCi/g (Umetco 1994a).

4.1.2 Club Ranch Ponds Area

The Club Ranch Evaporation Ponds (CRPs) Area consisted of six unlined liquid waste disposal ponds located down valley from the former mill site area and ancillary disposal areas. UCC constructed the CRPs in the early 1960s to serve as both evaporative and seepage discharge ponds. UCC excavated the ponds into gravel terrace deposits of the San Miguel River. The depths of the ponds ranged from approximately 8 feet to almost 30 feet. When operations ceased, Umetco estimated the ponds contained 560,000 cubic yards of raffinate crystals and 30 million gallons of liquid. Remedial investigations identified contaminants in the alluvial gravels and the underlying Kayenta Formation.

In the RAP, CDPHE selected a remedy for the CRPs Area that would excavate and dispose of (on site) raffinate crystals in the Burbank repository and dispose of other contaminated soils in the Tailings Piles on Club Mesa. The objectives of this remedy were to remove the source of potential future contamination of the Kayenta-Wingate aquifer and the San Miguel River (E2 2010).

Reclamation of the Club Ranch Ponds area occurred in three phases. Phase 1 consisted of the construction of two new lined evaporation ponds, the transfer of liquids from the unlined ponds to the lined ponds, and removal of raffinate crystals and contaminated soils from the unlined ponds into the repositories. Phase 2 covered the construction of additional lined ponds for collection and evaporation of contaminated groundwater and runoff during reclamation of the entire Site. Phase 3 included the removal and disposal (in the on-site repository) of pond liner materials, residual raffinate sediments, contaminated soils, and final grading and revegetation of the Site.

4.1.2.1 Phase 1 Remediation

Remedial activities began with the construction of two lined evaporation ponds (CRP-7 and CRP-8) in a portion of the Town Area. The new evaporation ponds were built to contain contaminated liquids from the other remedial activities conducted at Uravan. The ponds were constructed with leak detection systems and synthetic liners to eliminate contamination of underlying soils and groundwater. Construction started in September 1987, with the demolition and removal of town buildings and appurtenances from within the pond footprints. Approximately 43,000 cubic yards of contaminated soils were removed and placed in Tailings Piles 1 and 2. Confirmation surveys were completed in September 1987 for the CRP-7 area and in May 1988 for the CRP-8 area. CRP-7 and CRP-8 were completed and placed in use in May 1988, and June 1988, respectively. The pond construction activities were addressed in Compliance Reports CR-428-1, CR-428-2A, CR-428-2B, CR-428-3A, CR-428-3B, CR-428-4A, CR-428-4B, CR-428-5A, and CR-428-5B (CDPHE 2015a).

Dewatering of the unlined Club Ranch Ponds began after discharges to these ponds were redirected to CRP-7 on May 31, 1988. By December 24, 1988, all contaminated liquids had been transferred from the unlined ponds into the new lined ponds. This work was addressed in Compliance Report CR-401-2 (CDPHE 2015a).

Excavation of the raffinate crystals from the unlined ponds occurred between September 1989 and December 1990. Approximately 368,000 cubic yards of raffinate crystals were removed in accordance with Section 4.2.2.2 of the RAP and placed in the Burbank Repository. During 1990, contaminated soils were removed in accordance with the prescriptive, visual and radiological criteria cited in the RAP and transported to Tailings Pile 3. Approximately 40,100 cubic yards of contaminated soils were removed from under the upper ponds.

The removal of raffinate crystals in the lower ponds exposed cemented river terrace gravels which were initially left in place in anticipation of re-shaping these ponds for additional evaporative storage capacity. These gravels were removed during Phase 2 (refer to Section 4.1.2.2) (CDPHE 2015a).

4.1.2.2 Phase 2 Remediation

The plans and specifications for the construction of the additional lined ponds provided additional storage and evaporation of contaminated liquids while ensuring no additional seepage of these liquids into the subsoil or the groundwater. The approved design provided 36.1 acres of pond surface area, perimeter ditches to intercept offsite runoff, high-density polyethylene (HDPE) synthetic liners, 3 feet of freeboard for normal operating conditions including 1 foot of freeboard for emergency conditions and separate leak detection/collection systems for each pond. The 3 feet of freeboard specified was sufficient to contain a 100-year, 24-hour storm (and was in excess of the 25-year storm specified in the RAP) and designed to accommodate wave action/overspray (CDPHE 2015a).

The three upper ponds (CRP-1, CRP-4, and CRP-6) were re-shaped and lined between June 1990 and June 1992. The upper ponds were the only three out of the six original ponds that were reconstructed, and the lower ponds were held in reserve. Approximately 67,000 cubic yards of uncontaminated soil obtained from within the Club Ranch Ponds area were placed and compacted as dikes during re-shaping activities. Field Change Order FC-401-2 allowed the 12-inch clayey base material originally specified to be placed beneath the pond liner to be replaced by very low-density polyethylene (VLDPE) liner material. The VLDPE liner was substituted in the three ponds that were completed. As a design refinement and to expedite installation, the liner systems in CRP-4 and CRP-6 were upgraded to include a VLDPE secondary liner placed on the pond subgrade followed by an 8-ounce per square foot non-woven geotextile and an HDPE primary liner. In CRP-1, a 12-ounce per square foot non-woven geotextile was placed on the subgrade, followed by a VLDPE secondary liner and a HDPE primary liner.

Terrace gravels left in the bottoms of the lower ponds (CRP-2, CRP-3, and CRP-5) during Phase 1 were removed in 1998 to expose sandstone bedrock. This removal was in response to a groundwater remediation optimization program designed to remove fluids perched beneath the lower ponds. Approximately 32,800 cubic yards of contaminated river gravels were removed during the 1998 construction season and placed in Tailings Piles 1 and 2. The pond reconstruction activities are detailed in Compliance Reports CR-401-1, CR-401-3, CR-401-4, CR-401-5, and CR-401-6 (CDPHE 2015a).

4.1.2.3 Phase 3 Remediation

Cleanup activities were detailed in the *Characterization Report and Remedial Action Plan for the Club Ranch Ponds Area* dated June 2004, prepared in accordance with the *Characterization Investigation Plan for Club Ranch Ponds Area, Revision 1* dated June 1997. The plans required dewatering the ponds, the removal of raffinate crystal residue, removal of pond liner materials, removal of leak detection systems, and removal of contaminated material as dictated by verification survey and sampling. Upon completion of remediation and confirmation activities, drainage channels were established and the entire Club Ranch Ponds area was covered with a minimum 1-foot thickness of uncontaminated soil and seeded, in accordance with a field change order (*Final Grading and Drainage Plan for the Club Ranch Ponds Area*, dated June 2006).

Pond removal and remedial activities in the eight Club Ranch Ponds were conducted as follows:

Club Ranch Pond 1 (CRP-1)

Between July 2005 and August 2006, approximately 125,000 cubic yards of contaminated soils were removed from CRP-1 and the Caustic Pond area and placed in the B-Plant Repository. Approximately 14,000 cubic yards were excavated from the Caustic Pond area, the fence line below Highway 141, CRP-4 and CRP-6 and spread over the surface of the raffinate crystals in CRP-1 to stabilize the residues prior to being hauled to the repository. This activity is detailed in Compliance Report CR-401-7A (CDPHE 2015a).

Club Ranch Pond 2 (CRP-2)

The initial phase of remediation of the unlined CRP-2 and the adjacent area occurred between May and August 2001. This work consisted of the removal of trees, wood debris and contaminated soils from the area between the river and pond embankments. In addition, the work consisted of the removal of 1 foot of soil from the top and outside face of the pond embankments, the removal of 2 feet of soil from the inside face of the pond embankments and all the soil from the pond bottom. This work was detailed in the document *Uravan 2001 Project Work* submitted to CDPHE on April 10, 2001. Approximately 13,000 cubic yards of contaminated material was excavated and hauled to the B-Plant Repository for disposal during this period (CDPHE 2015a).

Final remediation occurred between December 2005 and June 2006. Approximately 45,000 cubic yards of contaminated material was excavated. Approximately 13,000 cubic yards of the total materials were temporarily placed in CRP-3 and -5 and Runoff Control Pond 3 to blend and stabilize wet soil. The stabilizing material was subsequently removed as part of the cleanup activities in those ponds. The remaining contaminated soil was hauled directly to the B-Plant Repository for disposal. These activities are detailed in the CDPHE approved Compliance Report CR-401-7B (CDPHE 2015a).

Club Ranch Pond 3 (CRP-3)

The initial cleanup from the unlined CRP-3 and the adjacent area occurred between April and September 2001. Approximately 6,000 cubic yards of contaminated soils from CRP-2 and the adjacent riverbank were placed in CRP-3 to help dry the material being hauled to the B-Plant Repository. Approximately 41,000 cubic yards of contaminated soil was excavated from CRP-3 of which 10,000 cubic yards was placed in CRP-7 to stabilize the crystal residues; the remaining material was transported to the B-Plant Repository for disposal. The soils in the uncontaminated portions of the embankments were sampled and tested in incremental segments to verify the absence of contamination. All the material verified as uncontaminated was stockpiled in the area for use during final grading activities (CDPHE 2015a).

Final remediation occurred during the 2005-2006 construction seasons. The approved remedial activities required the removal of one foot of altered soil from the road and center pond embankment, the removal of alluvial fill, the removal of a five-foot vertical wedge of altered material from the center pond embankment, the removal of contaminated material and the relocation of uncontaminated soils from the lower embankment. Approximately 50,000 cubic yards of contaminated soils were excavated from CRP-3 and the CRP-19 Well area between July 2005 and June 2006 and placed in the B-Plant Repository. The pond bottom area was excavated to bedrock. These activities are detailed in Compliance Report CR-401-7C (CDPHE 2015a).

Club Ranch Pond 4 (CRP-4)

Between July 2005 and June 2006, approximately 91,000 cubic yards of contaminated materials were removed from CRP-4 and the adjacent area. Approximately 2,000 cubic yards of contaminated materials were excavated from ancillary areas, including the caustic pond area, the fence line below Highway 141 and CRP-6, and placed in CRP-4 to stabilize the crystal residue. Approximately 23,000 cubic yards of dry contaminated soils excavated from CRP-4 were placed in CRP-1, CRP-5, CRP-8, and Runoff Control Pond 3 to stabilize wet material prior to being hauled to the B-Plant Repository. The remaining portion of the contaminated material was hauled directly to the B-Plant Repository for disposal. Residual contaminated material located in the southeast portion of CRP-4 required excavation to bedrock. This activity is detailed in Compliance Report CR-401-7D (CDPHE 2015a).

Club Ranch Pond 5 (CRP-5)

Cleanup initially started along the riverbank area adjacent to CRP-5. This work consisted of the removal of trees, wood debris and contaminated soils from the area between the river and pond embankments. Between June and September 2001, approximately 3,400 cubic yards of contaminated soils were excavated and placed in the B-Plant Repository (CDPHE 2015a).

Approximately 50,000 cubic yards of contaminated materials were removed from CRP-5 between July 2005 and June 2006 and placed in the B-Plant Repository. This material included approximately 33,000 cubic yards of contaminated material from CRP-2, CRP-3, CRP-4, and CRP-6, which had been spread out over the bottom of the pond to stabilize wet soils. The pond bottom area was excavated to bedrock. These activities are detailed in Compliance Report CR-401-7E (CDPHE 2015a).

Club Ranch Pond 6 (CRP-6)

Approximately 5,300 cubic yards of contaminated soils, from ancillary areas within the general ponds area, were excavated and placed in the CRP-6 pond bottom to stabilize the raffinate crystal. Approximately 17,400 cubic yards of raffinate crystal residue, liner system and underdrain piping debris were transported to the B-plant Repository for disposal between September and November 2003(CDPHE 2015a).

During the 2005 and 2006 construction seasons, approximately 26,000 cubic yards of contaminated soils were excavated from CRP-6. The majority of this material was placed in CRP-1, CRP-4 and CRP-5 in order to stabilize the raffinate crystal residues and wet soils prior to their placement in the B-Plant Repository. The remaining portion, approximately 11,000 cubic yards, was taken directly to the B-Plant Repository. These activities are detailed in Compliance Reports CR-401-7F and CR-401-7F (Part 2) (CDPHE 2015a).

Club Ranch Pond 7 (CRP-7)

Final remediation of CRP-7 included the removal of raffinate crystal residue and the liner and underdrain systems. Because CRP-7 was a new pond constructed in an uncontaminated area within the Club Ranch Ponds area with uncontaminated materials, little or no prescriptive excavation beneath the underdrain system was necessary to meet regulatory cleanup criteria. Contaminated soils were excavated from the embankments of CRP-2 and CRP-3 and the San Miguel riverbank between CRP-3 and CRP-8 and placed in CRP-7 between March and May, 2001.

The contaminated materials were placed over the raffinate crystals in a 2 to 3-foot thick layer to prevent the raffinate crystals from becoming airborne and to facilitate access and removal of the pond liner. A total of 17,900 cubic yards of contaminated material was placed in CRP-7. Raffinate crystals mixed with the contaminated soils, the pond liner and the underdrain system were removed between May and July, 2001. A total of 91,600 cubic yards of contaminated materials were removed and placed in the B-Plant Repository. This activity is detailed in Compliance Report CR-401-7G (CDPHE 2015a).

Club Ranch Pond 8 (CRP-8)

The approved remedial plan for CRP-8 required the removal of raffinate crystal residue, the liner and underdrain systems, and the relocation of uncontaminated soils from the embankments. Contaminated material from County Road EE-22, Highway 141, CRP-4 and CRP-6 was stockpiled in CRP-8 between January and June 2006. The stockpiled material was spread over the bottom of the pond to stabilize the wet raffinate crystal residue prior to its being transported and placed in the B-Plant Repository. Between July and September 2006, the approximately 69,000 cubic yards of contaminated materials, including the stockpiled material, crystal residue and liner/underdrain debris, were excavated from CRP-8 and placed in the B-Plant Repository. This activity is detailed in Compliance Report CR-401-7H (CDPHE 2015a).

Confirmation and Final Reclamation

On October 17, 2006, Umetco informed CDPHE that the RAP deadline for removal of the ponds and contaminated material within the Club Ranch Ponds area had been met. The *Confirmation Investigation Report, Club Ranch Ponds, Uravan, Colorado*, was submitted to CDPHE in June 2007. The report concluded that the remedial activities were successful. The average exposure rate was reduced to 19.3 µR/hr and met the RAP requirement. The average radium-226 concentration derived from field measurements and soil sampling for both surface subsurface soil samples met the RAP criteria. Individual grids with radium concentrations over 7.1 pCi/g are located in bedrock areas or within the 100-year floodplain of the San Miguel River. The average concentration of thorium-230 met the Category 2 criteria. Due to the high radium concentrations in the grids adjacent to the river, this area was included in Alternate Soils Standards application (refer to Section 4.1.7.6) (CDPHE 2015a).

Final grading activities were completed on October 22, 2007. Approximately 324,000 cubic yards of uncontaminated material were placed over the area to achieve the final grade and provide a minimum of 1 foot of cover soils. This uncontaminated material was obtained from the embankments of CRP-7 and CRP-8, which were originally constructed with material from the Valley Borrow area. Drainage channels were constructed and armored with riprap obtained from the Kaiser Quarry (CDPHE 2015a).

Revegetation activities were conducted between September and November 2007. Permanent fencing was installed between October and November 2007. The final reclamation activities are addressed in Compliance Report CR-401-8 (CDPHE 2015a).

4.1.3 River Ponds Area

The River Ponds Area consisted of seven small ponds constructed along the San Miguel River adjacent to the mill. Five of the ponds were located on the mill side (south side) of the river and

two ponds were located on the north side of the river adjacent to Colorado Highway 141. Mine operators constructed these ponds within old tailings piles by excavating into and, in some cases, through the tailings. UCC covered exposed surfaces of the excavations with natural soils. UCC used the five ponds on the mill side of the river as settling basins for liquids collected within the mill area and stored them there prior to discharge to the river. UCC used the two ponds on the north side of the river to clarify treated process liquors prior to discharge. These ponds contained neutralized sludge from clarification operations. Umetco estimated that the River Ponds Area contained about 290,000 cubic yards of mill wastes and contaminated soils. Seepage of liquids from the River Ponds Area to groundwater, and eventually to the San Miguel River, was estimated at 10 to 40 gallons per minute when they were in use (E2 2010).

In the RAP, CDPHE selected a remedy for the River Ponds Area that would excavate and dispose of (on site) all sludges and tailings in the Tailings Piles of Club Mesa. The objectives of this remedy were to remove the source of potential future contamination of the groundwater and the San Miguel River (E2 2010).

Tailings and contaminated materials were excavated from the River Ponds and placed on Tailings Piles 2 and 3. The initial removal occurred from October 1988 to May 1989. Excavation of contaminated material extended to below the water table, which was deeper than the excavation specification (i.e., where sandstone or siltstone bedrock or the water table is encountered, no additional material was removed and soil sampling was not necessary, as established in the CD/RAP for termination of excavation). Umetco agreed to perform additional excavation in areas of elevated scintillometer measurements from August 1990 to September 1990 because the water table dropped due to low river flows. In total, 332,500 cubic yards of contaminated material was excavated from the floodplain adjacent to the San Miguel River. Accordingly, contaminated materials and river gravels were excavated to below historic flow elevation of the San Miguel River and historic water table elevation.

Re-grading, back filling and re-vegetation was not required, since final reclamation activities were completed at a river flow rate of approximately 100 cfs. Alternatively, Umetco placed riprap jetties to enhance siltation and thus natural re-vegetation of the pond bottom (Umetco 1994c).

The Alternative Soil Standards Application (Umetco 2007a) notes that residual contamination from 20 to 60 µR/hr existed as local hot-spots prior to final excavation, and final verification surveys were not possible due to flooding of the area. These areas were covered by 2 to 3 feet of alluvial sediment and stabilized by riparian vegetation. Alternative standards were proposed for the area for the following reasons.

- Additional excavation would cause environmental harm by damaging the riparian vegetation and the wetland areas that have formed at the remediation site.
- The area met RAP exposure criteria of less than 20 µR/hr.
- No habitable structures would be constructed in the area because the area is within both the floodplain of the San Miguel River and the future DOE long-term surveillance area.
- Riprap groins and riparian vegetation form a stabilizing cover over the residual contaminants.

- The cost of remediation would be high compared to the relative decrease in human exposure.
- Previous remedial actions had reduced exposures to as low as reasonably achievable (ALARA).

The CDPHE accepted the Alternative Soil Standards Application in a letter dated September 26, 2007 (see Appendix C).

4.1.4 Tailings Piles

In the mid-1950s, UCC started to store tailings generated by the Uravan Mill in the Club Mesa Tailings Piles. The Tailings Piles are located on Club Mesa above the Uravan Mill. UCC constructed the Club Mesa Tailings Piles using the upstream method whereby the tailings slurry was pumped from the mill to the Tailings Piles and deposited through spigots placed along the tailings delivery line. The embankment raises were constructed from tailings sands that were re-graded, placed and compacted (E2 2010).

Prior to 1980, the downstream slopes on the tailings embankments varied from approximately 1.5(H):1(V) to 3(H):1(V). As the height of the embankment increased, there was concern for the stability of the embankments. Consequently, in 1980, UCC constructed rockfill berms, including a drainage blanket, for seepage control to buttress the lower portions of the Tailings Piles. UCC also installed horizontal drains to promote drainage of the tailings; however, these drains were ineffective (E2 2010).

Observed impacts from the tailings disposal system included seepage of contaminated liquids into the Club Mesa bedrock; erosion and transport of tailings material away from the disposal area by wind and water action; and radon emanation from the Tailings Piles (E2 2010).

In the RAP, CDPHE selected a remedy for the Tailings Pile that would cease the discharge to the Tailings Piles, remove the liquids, and cover the slopes of the Tailings Piles material prior to final reclamation. The objectives of this remedy were to minimize surface water infiltration, seepage from the Tailings Piles, wind and water erosion, and radon emanation from the Tailings Piles (E2 2010).

Remedial activities set forth in the RAP for the tailings piles of Club Mesa included dewatering, pile reshaping, buttress protection, toe drain system maintenance, top and side slope cover construction, and storm water drainage diversion. The RAP called for dewatering through natural seepage enhanced by surcharging caused by additional materials placed on the piles (E2 2010).

Prior to final closure, the tailings piles were used for disposal of contaminated materials generated during other Site remediation activities. Approximately 1.3 million cubic yards of contaminated materials (soils, tailings, sludge, concrete rubble, building scrap, and debris from cleanup projects) were placed on Tailings Piles 1 and 2 from December 1987 to April 2002 as documented in Compliance Report CR-404-2. Tailings Pile 3 accepted 306,000 cubic yards of contaminated material from July 1988 to August 1990, as documented in Compliance Report CR-405-2.

As required by the CD/RAP, the closure actions for the two Tailings Pile disposal structures were subdivided into six different components: dewatering; slopes and contours; rockfill buttress and toe drain systems; side slopes protective cover; top cover; and drainage diversion. Final cover thicknesses, grading and drainage plans, as required to supplement the RAP requirements were designed, reviewed, and approved by CDPHE (E2 2010).

Dewatering

Dewatering activities included the construction of shallow trenches and channels leading to collection/transfer basins and/or sumps. All collected fluids were transferred to one or more of the lined Club Ranch Ponds for evaporation in accordance with RAP requirements. Waste materials were placed on the Tailings Piles to surcharge the structures and accelerate dewatering drainage (E2 2010) Dewatering activities are documented in Compliance Reports CR-404-1 (Tailings Piles 1 and 2) and CR-405-1 (Tailings Pile 3).

Rock Fill Buttress and Toe Drains

The existing rockfill buttresses previously placed to stabilize the tailing slopes were covered with 4 feet of 48 inch minus erosion protection rock material obtained from the Burbank Quarry. The existing toe drain system was maintained until seepage ceased in 2003. The toe drains were subsequently grouted shut as documented in Compliance Reports CR-404-7B (Tailings Piles 1 and 2) and CR-405-7B (Tailings Pile 3). During operation, toe drain liquids, were collected and transferred to the Club Ranch Ponds for evaporation as required by the CD/RAP (E2 2010). Construction of rock-fill buttresses and toe drains are documented in Compliance Reports CR-404-3A (Tailings Piles 1 and 2) and CR-405-3A (Tailings Pile 3).

Side Slope Reclamation Cover

The covers on the existing re-graded tailings portion of the slopes consisted of a 0.3-meter (1 foot) layer of random interim cover material, 0.9 meters (3 feet) of compacted (radon barrier) clay, 0.9 meters (3 feet) of random (frost barrier) fill and 1.2 meter (4 feet) of 48-inch minus riprap rock for a total thickness of 3.3 meters (11 feet) measured perpendicular to the slope. The original RAP specified cover on the new 5(H):1(V) portion of the slopes, where contaminated soils from the various remedial activities were placed, consisted of 0.9 meters (3 feet) of compacted (radon barrier) clay, 1.5 meters (5 feet) of random (frost barrier) fill and 0.6 meters (2 feet) of 12-inch minus riprap rock for a total thickness of 3.0 meters (10 feet). Design Change Orders reviewed and approved by CDPHE on June 14, 2000 and February 22, 2002 for Tailings Pile 3 and 1 and 2 respectively, modified the thickness of the final side slope covers to include 3 feet of compacted radon barrier clay, 6 feet of random frost barrier fill and 1 foot of 12 inch minus erosion protection riprap on the 5(H):1(V) slopes of both disposal structures. Erosion protection riprap was obtained from the Burbank Quarry and the State-approved Kaiser Quarry. Random fill and clay materials were obtained from the Surprise Borrow area and the State-approved Elk Borrow area (E2 2010) Side slope management activities are documented in Compliance Reports CR-404-4 (Tailings Piles 1 and 2) and CR-405-4 (Tailings Pile 3).

Top Cover

The conceptual design required in the RAP provided for a 3 percent grade on the top surfaces of each of the two disposal structures, sloping from the crest to the back or abutment of the structures with drainage channels located at the contact between the reclamation cover and the

existing sandstone abutments at the back of the structures. Design change orders reviewed and approved by CDPHE on June 14, 2000 and February 22, 2002 for Tailings Pile 3 and 1 and 2 respectively, provided for modification of cover drainage patterns, while still maintaining a positive 3 percent grade. The design change order also realigned diversion channels to direct runoff flows away from the contact between the reclamation covers and sandstone abutments to reduce infiltration at the interface and provided a catchment apron to prevent potential rockfalls from the sandstone rims above the structures from blocking permanent drainage channels. The design modifications also provided for blasting and recontouring (laying back) of the natural sandstone rims above both disposal structures. The thickness of the final cover material components is the same as that required for the 5(H):1(V) side slopes (E2 2010). Top cover activities, including change orders, are documented in Compliance Reports CR-404-5, CR-404-5A, CR-404-5B (Tailings Piles 1 and 2), CR-405-5, CR-405-5A, and CR-405-5B (Tailings Pile 3).

Drainage Diversion

Drainage from the areas above and adjacent to the Tailings Pile structures and precipitation runoff from the piles are controlled. The drainage diversion system was designed and constructed as follows:

- The Club Mesa Spray area runoff was directed away from the Tailings Piles by contour grading of the spray area and constructing a cut and fill diversion channel located a minimum of 100 feet away from the crest of the sandstone rim above the tailings piles. The diversion channel was designed to pass the probable maximum flood (PMF) with a minimum of 1 foot of freeboard and constructed to minimize erosion by providing minimum invert slope grades. The riprap erosion protection was sized to withstand PMF velocities and was obtained from the State-approved Burbank Quarry.

- Drainage from the top surfaces and adjacent to the Tailings Pile structures is intercepted by drainage channels at the back of the piles as described previously. The runoff from both structures is conveyed through a channel cut into the sandstone rim which separated the structures to a natural gully located to the north of Tailings Pile 1 and 2. The diversion channels were designed to pass the PMF with a minimum of 1 foot of freeboard and constructed to minimize erosion by providing minimum invert slope grades. The riprap erosion protection was sized to withstand PMF velocities and obtained from the State-approved Burbank Quarry.

- Surface runoff from the top surface of the Tailings Piles is directed away from the embankment face or crest at a maximum 3 percent grade and collected and conveyed to the channels and natural gully described above.

- Surface runoff from the faces of the covered tailings embankments is dispersed over the sandstone bedrock foundation surface and away from the structures by graded dispersion aprons and turnout structures at the toes of the slopes. Turnout structures are located to convey runoff flows to the cliff faces where long-term cliff retreat will not impact the disposal sites.

Drainage diversions are documented in Compliance Reports CR-404-6 (Tailings Piles 1 and 2) and CR-405-6 (Tailings Pile 3). Final reclamation of the Tailings Pile 1 and 2, and 3 disposal structures was completed in 2007(E2 2010).

4.1.4.1 B-Plant Repository

Performance characterization work required by the CD/RAP resulted in a significant increase in the volume of contaminated materials than was originally anticipated. Accordingly, an additional repository, B-Plant Repository, was designed and constructed. Umetco began the B-Plant repository construction and operations and placement of contaminated materials in 1998. A toe drain system was also installed in the B Plant Repository Area. This capped repository accepted contaminated materials from the final reclamation of the Club Ranch Ponds and has a designed capacity of approximately 1.8 million cubic yards of waste material. Approximately 834,000 cubic yards of contaminated materials from various cleanup activities were placed in the repository from 1998 to 2007. Sources of contaminated materials from placed in the B-Plant Repository include the Town Dump Areas; A and B-Plant areas; Mill Hillside; Water Storage Ponds; Northeast Colorado Highway 141; Frog Pond; Electrical Sub-Station; County Roads EE-22 and Y-11; former Runoff Control Ponds 1, 2, and 3; Town Area; and the Club Ranch Pond Area. Additional minor quantities of 11e (2) byproduct material were received from CDPHE Gateway Mill Clean-up Project, CDOT Highway 141 realignment project, Colorado School of Mines Research Institute, and Table Mountain Research Center (E2 2010). Design and construction of the plant is documented in Compliance Report CR-404-8. Placement of waste is detailed in Compliance Reports CR-404-9 and CR-404-13 through CR-404-16.

The reclamation cover for the B-Plant Repository consists of a minimum 1.5-foot thick clay radon barrier, 4.5-foot thick frost protection layer and 1- to 8-foot thick rock riprap erosion protection layer (E2 2010). Reclamation activities are documented in Compliance Reports CR-404-10 through CR-404-12.

4.1.5 Club Mesa Area

Umetco estimated that the Club Mesa Area (also known as the Club Mesa Spray Disposal Area or Club Mesa Raffinate Spray Disposal Area) housed approximately 484,000 cubic yards of contaminated materials. These materials included 250,000 cubic yards of raffinate crystals, 150,000 cubic yards of neutralized sludge, 40,000 cubic yards of contaminated pond material, and 44,000 cubic yards of contaminated soils in the fringe area (E2 2010).

Superficial and subsurface contamination occurred as a result of the raffinate spray process. Superficial contamination is due to the presence of the raffinate crystals in addition to the windblown spray, which contaminated soils in the adjacent fringe area. Subsurface contamination is caused by seepage of excess spray liquids into the underlying soils and bedrock through the unlined surface of the spray area (E2 2010).

In the RAP, CDPHE selected a remedy for the Club Mesa Area that would excavate and dispose of (on site) the raffinate crystals in the former Burbank Quarry (now known as the Burbank Repository) and dispose of other contaminated soils in the Tailings Piles on the Club Mesa. The objective of this remedy was to remove the source of future potential contamination of surrounding soils and the underlying soils and bedrock (E2 2010).

Remedial activities in the Club Mesa Area fell into four phases: construction of temporary surface water controls, removal and confirmation investigation of contaminated material, remediation of mine portals and subsidence areas, and final site remediation. These phases are described below (CDPHE 2015a).

Surface runoff and drainage controls were designed to contain and control discharges from 10-year, 24-hour storms during remediation and reclamation at this area. Originally, the plan required the construction of two unlined ditches to divert runoff away from the Tailings Piles. However, the ditches were not installed due to topographic constraints; instead, two existing sediment basins, SB-8 and SB-9, were utilized to collect liquids, which were routinely transferred to the Club Ranch Ponds for evaporation during the initial cleanup. In 1997, SB-8 was removed, SB-9 was reconstructed to include a lined spillway, and two additional lined runoff control basins, RC-5 and RC-6 were constructed. The three basins, along with two 36-inch diameter corrugated metal pipe culverts under a haul road, were then used to control runoff during reclamation. Upon completion of final reclamation activities, these temporary runoff control structures were removed and disposed of in the Tailings Piles, and these areas were vegetated. This work segment was detailed in Compliance Report CR-406-1 (CDPHE 2015a).

Cleanup of contaminated materials took place in stages beginning in September 1989 with the removal of neutralized sludge. Approximately 165,000 cubic yards of raffinate crystals were excavated in 1990, 1991 and 1992 and placed in the Burbank Crystal Repository. Approximately 117,000 cubic yards of contaminated soils and 121,000 cubic yards of neutralized sludge were removed and placed on top of the Tailings Piles between 1989 and 1994. Prior to removal of contaminated soils from the storage ponds, the liquids contained in these ponds were transferred to the Club Ranch Ponds for evaporation. The two storage pond embankments were subsequently breached and graded so that no liquid would collect. Material removal was completed in May 1994 (CDPHE 2015a).

During 1996, a preliminary confirmation investigation survey was conducted in preparation for the final reclamation design. As a result, an additional 150,000 cubic yards soil was removed and placed on the top of Tailings Piles 1 and 2 by January 1998. Overall, the entire Club Mesa Spray Disposal Area was excavated to expose sandstone bedrock in accordance with the cleanup criteria set forth in Section 4.5.2 of the RAP. The removal activities were detailed in Compliance Report CR-406-2 dated February 27, 1998 and approved by CDPHE (CDPHE 2015a).

Upon completion of the contamination removal, confirmation investigations were conducted including gamma surveys, bedrock samples, radon emanation measurements from the spray area, and a risk assessment. The results concluded that even though naturally occurring uranium ores are present in some of the exposed bedrock, the average activity of the un-mineralized areas was less than 5 pCi/g radium-226 above background and does not pose significant future health risk to individuals. The results also indicated radon flux ranges from 0.04 to 3.6 picocuries per square meter per second (pCi/m^2s) with an average of 1.2 pCi/m^2s, below the regulatory standard of 20 pCi/m^2s for repository covers. These activities formed the basis of the final reclamation design, and were reported in Compliance Report CR-406-5 (CDPHE 2015a).

The subsided areas, shafts and mine portals shown in the original plans as well as seventeen other mine features encountered during the soil cleanup activities in the area were backfilled with uncontaminated rock rubble and soil materials from the Burbank Quarry and Upper Club Mesa Borrow Area. This work was conducted in 1994 after the majority of the soil cleanup activities were complete. Additional subsidence areas, shafts, and portals discovered during final cleanup of the area were closed during 1997. This work was detailed in Compliance Report CR-406-3, dated February 27, 1998 and approved by CDPHE (CDPHE 2015a).

The final reclamation activities were governed by the *Final Plans, Specification and Quality Plan for Club Mesa Final Reclamation*, submitted February 27, 1998 and approved by CDPHE on June 30, 1998. This document included construction of permanent drainage features designed to control probable maximum precipitation flood events, and the grading, backfilling and covering of specified areas with erosion resistant rockfill materials to minimize offsite sediment transport, create a natural appearance and promote the establishment of natural vegetation. The permanent drainage features consisted of a haul road embankment, which bisected the Club Mesa Spray Disposal Area, and a channeling swale leading to a runoff diversion berm/channel and channeling fill areas. These structures were constructed using over 137,000 cubic yards of random fill and approximately 39,000 cubic yards of Type B riprap. In addition, over 17,000 cubic yards of rock mulch material were used to fill depressions and reduce erosion in the specific areas required in the approved plans and drawings. The earthwork was completed by March 1998. Seeding was performed in April 1998. The final reclamation activities were detailed in Compliance Report CR-406-6, approved by CDPHE on December 18, 2001 (CDPHE 2015a).

4.1.6 Mill Areas

The Mill Areas include the A-Plant in the valley northwest of the Club Mesa Tailings Piles; the B-Plant; Ore Stockpile Area; Barrel Storage Area, the Heap Leach site on a bench below and east of Club Mesa Tailings Pile 2, and the Bone Yard for miscellaneous scrap equipment located west of Tailings Pile 2. Radioactive material resulting from Uravan operations impacted all of these areas (E2 2010).

The mill process area consisted of the A-Plant and B-Plant and included the uranium and/or vanadium milling systems and ancillary facilities located along the San Miguel River valley floor at the base of Club Mesa and the facilities located on the canyon face and lower bench immediately next to the Club Mesa Tailings Piles. The mill system included ore receiving bins and crushing and sampling plan, aerofall grinding circuit, crushed and ground ore storage bins, hot sulfuric acid leach circuit, counter-current decantation circuit, sulfuric acid generation plant, uranium ion exchange circuit, uranium precipitation and calcining circuits, vanadium salt roast leach circuit, vanadium fusion circuit, metallurgical control laboratory and solution transfer system. The mill system also included ancillary facilities such as reagent storage and mix systems, fuel distribution/ storage systems, steam generation systems, electrical distribution systems, equipment maintenance facilities and office and warehouse facilities. Mill operations facilities consisted of maintenance to office, warehouse, electrical and liquid transfer systems (E2 2010).

In the RAP, CDPHE selected excavation and onsite disposal of contaminated equipment, structure, waste materials, contaminated soils and ancillary contaminated materials into the Club Mesa Tailings Piles, the Burbank Quarry or a disposal site in the Elk Claim Area as the remedy for the

Mill Area. The objective of this remedy was to remove the source of future potential contamination of surrounding soils and the underlying soils and bedrock (E2 2010).

4.1.6.1 A-Plant Area

Remedial activities in the A-Plant area were initiated in June 1990 and continued intermittently through 2002 and consisted of the decommissioning of mill structures, the removal and confirmation of contaminated material, and the final site remediation (CDPHE 2015a).

Decommissioning at the A-Plant began with the removal of small amounts of asbestos containing material from two tanks in June 1990. During 1993, friable asbestos and asbestos insulation were removed from the Power House, the Community Building and all outside piping. The asbestos was disposed of in Tailings Piles 1 and 2 (CDPHE 2015a).

The Uravan Mill Decommissioning Plan, approved by CDPHE on October 14, 1993, required the demolition and removal of 91 structures, including buildings and mill processing equipment, from the A-Plant area. The plan provided procedures for the development of Dismantling and Demolition Plans for each of the mill structures to be removed. The subsequent individual Dismantling and Demolition Plans were submitted to CDPHE for approval prior to commencement of the work. Decommissioning began in February 1994 with additional asbestos abatement of mostly transite siding. The structures were demolished after final asbestos monitoring was conducted and clearance given on March 15, 1995. The majority of the structures were demolished by 1997. Approximately 23,500 cubic yards of sized concrete, metal and other building debris were placed in Tailings Piles 1 and 2, with the exception of the metal Office Building, which was dismantled, decontaminated and donated to the Montrose County Transportation Department in 1997(CDPHE 2015a).

Between March 1995 and June 2002, approximately 481,000 cubic yards of contaminated soils were removed from the A-Plant area, including the mouth of Hieroglyphic Canyon, the Treasure Island storage area and around the Historic Structures (the Community Center and the Boarding House). In general, the contaminated soils were removed to expose the sandstone bedrock. Decommissioning of the A-Plant was detailed in Compliance Report CR-413-6, approved by CDPHE on January 14, 2003, and Confirmation Investigation Report, A-Plant, approved by CDPHE on January 30, 2003 (CDPHE 2015a).

Removal of contaminated material in the A-Plant North Area was initiated in October 2006 and continued through June 2007. The reclamation included the removal of approximately 17,500 cubic yards of material and debris associated with a runoff control pond, work trailers and wheel wash facility located next to the San Miguel River. This material was placed on the B-Plant Repository (CDPHE 2015a).

Confirmation investigations of the A-Plant area were conducted between 1998 and 2002 using the procedures set forth in *Soil Cleanup Methodology for Uravan, Colorado* as well as site-specific documents regarding data collection and evaluation. The investigation included exposure rate surveys and surface and subsurface soil samples of radionuclides and metals. The results of this investigation were detailed in *Confirmation Investigation Report, A-Plant, Uravan, Colorado*, dated December 2002. Average exposure rates and contaminant concentrations in soil were reduced to

levels below the Category 2 soil cleanup objectives given in the Soil Cleanup Methodology (Umetco 1999a) (CDPHE 2015a).

Confirmation investigation was also conducted in the A-Plant North area, and detailed in the Appendix to the *Confirmation Investigation Report, A-Plant, Uravan, Colorado*, for A-Plant North (Compliance Report CR-413-8) dated October 25, 2007 and approved by CDPHE on November 12, 2007. The results indicated the average exposure rate met the RAP cleanup criteria and the average heavy metal concentrations were less that the Category 2 criteria given in the Soil Cleanup Methodology (Umetco 1999a) (CDPHE 2015a).

Alternative soils standards were applied to the steep slopes on the north side of the A-plant area in the Alternative Soil Standards Application (Umetco 2007a). Residual gamma exposure was documented to average 21.47 µR/hr with a maximum exposure of 45.1 µR/hr for a single 10-by-10-meter grid in the area. Ra-226 levels were noted to average 5.37 pCi/g with a maximum reading of 28.38 pCi/g for a single 10-by-10-meter grid. Alternative standards were proposed for the following reasons:

- Additional remediation in the floodplain of the San Miguel River would cause excessive environmental harm to the wetland areas.
- Residual Ra-226 contamination was relatively low and did not pose a risk to recreational users or the environment. No habitable structures would be constructed in the area.
- The cost of future remedial actions would exceed benefits because potential human exposures are negligible.
- Previous remedial actions had reduced exposure to ALARA.
- Future land use would be habitat for wildlife and not for residential or related structures. The DOE will assume long-term stewardship of the property and manage land use.

Confirmation surveys were performed in the Historic Structures area in March and April 2007, and the results showed that the RAP cleanup criteria have been met. This work was detailed in Compliance Report CR-418A-1 dated January 30, 2008 and approved by CDPHE. On April 17, 2007, a CDPHE inspector surveyed the area and verified that the cleanup was completed (CDPHE 2015a).

Final reclamation was performed between April and September 2003, including removal of the runoff control ponds, rock mulch and rock rubble placement, sediment dam construction, grading, and revegetation. The rock mulch and rock rubble were spread over the exposed sandstone bedrock to provide a stable erosion resistant seed bed and to create gentle slopes to the river. The reclamation work was detailed in Compliance Report CR-413-7and CR-418A-1 (CDPHE 2015a).

Boarding House and Community Center

The Boarding House and the Community Center buildings (Historic Structures) in the A-Plant area were demolished in February 2007. Approximately 5,000 cubic yards of building debris and contaminated soils from beneath and immediately surrounding the demolished buildings were

excavated and placed in the B-Plant Repository in March 2007. The area previously occupied by the Historic Structures was graded to gently slope towards Hieroglyphic Canyon and then covered with rock mulch. The rock mulch seed beds were disked, fertilized and seeded. The demolition, cleanup, confirmation surveys, and reclamation of these two buildings were detailed in Compliance Report CR-418A (CDPHE 2015a).

On February 18, 2005, EPA deleted a portion of the Site from the NPL. This partial deletion pertains to 9.84 acres previously containing the Boarding House and the Community Center.

4.1.6.2 B-Plant Area

Remedial activities in the B-Plant area were initiated in August 1986 and continued intermittently through September 2002 and consisted of the decommissioning of mill structures, the removal and confirmation of contaminated material and the final site remediation (CDPHE 2015a).

Removal of ore grade and partially processed ore materials from the Ore Stockpile and Heap Leach areas began in late August 1986. A total of 18,000 tons of ore grade materials were transported to the White Mesa Mill in Blanding, Utah, by mid-October 1986. This work was detailed in Compliance Report CR-413-2, approved by CDPHE on December 19, 2001. (CDPHE 2015a).

The inventory of the barrels was completed on December 10, 1987. Barrels containing radioactive materials and non-Resource Conservation and Recovery Act (RCRA) waste products were disposed of in Tailings Piles 1 and 2. Barrels containing feed grade materials were transferred to the White Mesa mill in Blanding, Utah for processing along with barrels containing new commercial products, oils, resins, etc. Drums of waste oil were transferred to an approved offsite disposal facility. Empty barrels were reduced in volume and placed into Tailings Piles 1 and 2. All barrels were removed by January 22, 1988. This work was detailed in Compliance Report CR-413-3 dated January 26, 1988, and approved by CDPHE (CDPHE 2015a).

The removal of debris, clay base, and contaminated soils from the Bone Yard, Barrel Storage Area, Ore Stockpile Area and Heap Leach Site occurred intermittently from 1987 through the end of 1989. Approximately 96,000 cubic yards of material were excavated, to expose the sandstone bedrock, and placed on the top of Tailings Pile No. 3. These work segments were detailed in Compliance Reports CR-413-1, CR-413-2, CR-413-4 and CR-413-5, which were approved by CDPHE (CDPHE 2015a).

On October 17, 1989, Umetco requested permission to remove the wooden thickener (Counter-Current Decantation) tanks. The request was granted by CDPHE on January 5, 1990 as a modification to the RAP. The tanks were dismantled and placed in Tailings Piles 1 and 2 between March 1990 and January 1991 (CDPHE 2015a).

The Uravan Mill Decommissioning Plan, which included procedures to develop Dismantling and Demolition Plans for each of the B-Plant mill structures, was approved by CDPHE on October 14, 1993. Subsequent individual Dismantling and Demolition Plans were submitted to CDPHE for approval prior to commencement of the work. Decommissioning took place in 1995 and involved the removal of asbestos containing material, the demolition of all forty-eight structures and the removal of approximately 65,000 cubic yards of contaminated soils (CDPHE 2015a).

The final cleanup of the B-Plant area took place intermittently between August 1997 and November 1999 and involved the removal of all loose material from the bedrock surface. An additional 290,000 cubic yards of contaminated soil was removed during this period. Slimes resulting from the Heap Leach process area were removed between 2000 and 2002. Contaminated soils in this area were generally removed until bedrock was encountered. This bedrock contains naturally occurring subgrade uranium ore. This work was detailed in Compliance Report CR-413- *and Confirmation Investigation Report, B-Plant* (CDPHE 2015a).

Confirmation surveys of the B-Plant area were conducted between 1999 and 2002 using the procedures set forth in *Soil Cleanup Methodology for Uravan, Colorado* as well as site-specific documents regarding data collection and evaluation. The investigation included exposure rate surveys and surface and subsurface soil samples of radionuclides and metals. The results of this investigation were detailed in *Confirmation Investigation Report, B-Plant, Uravan, Colorado*, which was submitted to CDPHE on December 21, 2002, and approved on February 6, 2003. As noted in the report, in general, the contaminated soils were removed to bedrock, which exposed naturally occurring subgrade uranium ore. The average contaminant concentrations in soil were reduced to levels below the appropriate soil cleanup objectives given in the Soil Cleanup Methodology (Umetco 1999a) (CDPHE 2015a).

Final reclamation was performed between April and September 2003, including removal of the runoff control ponds, rock mulch and rock rubble placement, sediment dam construction, grading, and revegetation. The rock mulch material was spread over the level surfaces and minor depressions in the B-Plant area to provide a stable erosion resistant seed bed. The rock mulch was then disked, fertilized and seeded. Type C riprap (48-inch minus) was placed in the three drainages leading from the B-Plant area to establish permeable sediment trap dams. This work is detailed in Compliance Report CR-413-7 (CDPHE 2015a).

4.1.7 Town and Adjacent Areas

The former Town of Uravan occupied the San Miguel River valley area just northeast of Tailings Piles 1 and 2. Adjacent areas were the town dumps (Old Town Dump and New Town Dump), which were located on the south side of the San Miguel River, south of Colorado Highway 141 and west of CRP-4; and areas adjacent to the town affected by deposition by windblown materials, including the Hieroglyphic Canyon, San Miguel River and Atkinson Creek drainage (E2 2010).

UCC used tailings in localized construction activities that were spilled from delivery pipelines running through the Town Area. Wind and surface water transported tailings were found in the town and adjacent drainages. CDOT routed Colorado Highway 141 over an old WWII mill and associated tailings (E2 2010).

In the RAP, CDPHE selected a remedy for the Town and Adjacent Areas that would excavate and dispose of (on site) Town Area contaminated materials, waste from the Town Dumps, remnant tailings, streams and storm water drainage deposits, and windblown material into the Club Mesa Tailings Piles repositories, the Burbank Quarry or disposal site in the Elk Creek Claim Area. The objectives of this remedy were to remove the source of future potential contamination of surrounding soils, underlying soils, groundwater and surface water (E2 2010).

All Uravan residents were relocated as of 1986. From 1987 to 1994, Umetco removed all housing structures (approximately 260) from the former Town of Uravan and removed and transported contaminated soils to the Club Mesa Tailings Piles. Umetco graded and re-vegetated the Town Area in 2000 after soil verification studies were completed and accepted (E2 2010). Details regarding remediation of the town and adjacent areas are included in the subsections below.

4.1.7.1 Town Area

The Town Area encompassed the areas known as A-Block, B-Block, G-Block, H-Block and J-Block Housing Areas, the Trailer Court, the Old Trailer Court, the Flat Tops, the Sewage Treatment Plant, and the Atomic Energy Commission Pile. Remedial activities were initiated in early 1987 with the removal of structures, vegetation and contaminated soils from the footprint of new evaporation ponds CRP-7 and CRP-8 (refer to Section 3.1.2). The remaining structures and contaminated materials were removed between September 1989 and December 1994. Over 200,000 cubic yards of contaminated material were removed and placed in Tailings Piles. This work was detailed in Compliance Report CR-418G-2. (CDPHE 2015a).

Initial confirmation surveys were performed in 1995 and resulted in approximately 24,000 cubic yards of contaminated material to be removed and placed in the B-Plant Repository in 1998 and 2000. Additional confirmation surveys were conducted between 1999 and 2003. Overall, post-remedial conditions were evaluated using exposure rates surveys and soil assay, and the results were detailed in the *Confirmation Investigation Report, Town Area, Uravan, Colorado* (CR-418G-3) dated June 2003. The report indicated that the average exposure rate and the average radium-226 concentration met the requirements of the RAP, and the average contaminant concentrations in soils have been reduced to levels below appropriate soil cleanup objectives given in the Soil Cleanup Methodology (Umetco 1999a) (CDPHE 2015a).

Final reclamation and vegetation activities took place between October and December 2000 in accordance with the *Final Grading Plan, Town Area*, dated October 16, 2000. In general, the area was graded to a natural appearance by removing sharp contours and steep slopes and backfilling major depressions. Long or steep drainage paths were reduced by pocking the ground surface and providing cross drainage contouring and water bar contouring. The plan also required the construction of runoff control structures including a grouted riprap discharge chute from an existing culvert under Highway 141 and a shallow discharge channel with a small rockfill sediment trap to drain runoff from the other existing culvert under the highway. Vegetation activities were performed in November 2000, in accordance with the Revised Revegetation Specification approved by CDPHE on November 20, 2000. Final reclamation activities were detailed in Compliance Report CR-418G-4 (CDPHE 2015a).

Approximately 12,000 cubic yards of remnant tailings were removed from the entrance road to the B-Block area and placed in Tailings Pile 3 in 1989. Discrete deposits of tailings and contaminated materials were also removed from the gas station area, Atomic Energy Commission pile, B-Block septic tank and leach field area, G-Block septic tank and leach field, and the new trailer court septic tank and leach field. Final cleanup, confirmation surveys, and final reclamation were included in the Town Area (refer to Section 4.1.7.1 of this report). The details of this work segment were given in Compliance Report CR-418-3A (CDPHE 2015a).

4.1.7.2 Town Dump

The Town Dump area is split into the New Town Dump and the Old Town Dump, located on the south side and the north side of County Road Y-11, respectively (CDPHE 2015a).

In August 1988, a total of 16 trenches were excavated through the trash zone into several feet of clean material. Visual examinations of the material in the trenches are described in the Town Dump Investigation dated August 24, 1988, attached to Compliance Report CR-418-2. On December 4, 1990, CDPHE required the submittal of Plans and Specifications for the removal and reclamation as the results of the report indicated heavy metals and radionuclide contamination were present. The plans and specifications were approved by CDPHE on April 6, 1998 (CDPHE 2015a)

Preparatory work at the Town Dump Area began on May 11, 1998, with the construction of runoff control and decontamination facilities. Surface water ditches and lined ponds were constructed during May and June 1998. Minor modifications to the ponds and ditches in the Old Town Dump were made to ease construction. The Design Engineer approved all the modifications to the ponds. This work segment is detailed in Compliance Report CR-419-1 (CDPHE 2015a).

The removal of contaminated materials from the Old Town Dump occurred in June 1998. Contaminated materials at the New Town Dump were excavated and removed between July and November 1998. Approximately 257,600 cubic yards of contaminated materials were placed in the B-Plant Repository. Post excavation verification surveys in December 1998 and May 1999 and indicated contaminated material remained at the New Town Dump. Approximately 6,570 cubic yards were excavated in April 1999 and 42 cubic yards were excavated in September and October 1999 and placed in the B-Plant Repository. The remediation work was detailed in Compliance Report CR-419-2, (CDPHE 2015a).

A final verification was performed in October 1999. The *Confirmation Investigation Report, The Town Dump, Uravan, Colorado* was submitted to the CDPHE for review and approval on December 21, 1999. The report concluded the cleanup activities were successful. The average exposure rate (14 µR/hr) met the RAP criterion as did the average concentration of Ra-226 (2.5 pCi/g). All laboratory analytical results for radium-226, arsenic, cadmium, lead, nickel, selenium, and zinc in both surface and subsurface soils met RAP Category 1 objectives. Some confirmation soil samples exceeded Category 1 objectives but were below Category 2 objectives for uranium, molybdenum, and vanadium. One surface soil sample for thorium-230 exceeded Category 2 surface soil objectives. This sample was less than the Category 1 subsurface soil objective; therefore, Umetco proposed the placement of a minimum of 15 centimeters of uncontaminated fill as shown in the final grading plan included in the confirmation report. Implementation of the grading plan provided the necessary stable backfill for the appropriate application of subsurface RAP objectives and to restore the site to conditions similar to the surrounding environment. Implementation of the grading plan minimized the potential future risks to individuals from the current steep slopes and minor residual soil contamination. CDPHE approved the report on December 29, 1999. Confirmation activities are detailed in Compliance Report CR-419-3 (CDPHE 2015a).

Final reclamation activities were performed in May and June 2000, in accordance with the plan detailed in the approved Confirmation Investigation Report. Both former dump areas were graded to blend with the surrounding topography. The vegetation activities were conducted in

November 2000 in accordance with the Revegetation Specifications, approved by CDPHE on November 20, 2000. The final reclamation was completed before the modified RAP deadline dates, approved by CDPHE on March 22, 2000, and detailed in Compliance Report CR-419-4 (CDPHE 2015a).

4.1.7.3 Windblown Area

The windblown materials are defined in the RAP as mill-derived contaminants dispersed by the wind into the surrounding areas. This material was most likely mill tailings blown from Tailings Piles. The windblown area also contains naturally occurring radioactive materials (uranium ore and sub-grade ore) and mine-related materials such as waste rock piles. These materials are not milling related, they are not regulated by the RAP or CDPHE Radioactive Materials License 660-02, but rather are associated with mine regulations, permits, and associated reclamation activities. Section 4.7.2.4 of the RAP states windblown deposits do not require removal due to the thin soils and environmentally sensitive nature of the Club Mesa area. However, the RAP does require the removal of concentrated, contaminated mill-related deposits with exposure rates greater than 30 µR/hr. The *Characterization Investigation Plan for Windblown Material, Revision 1*, was submitted October 20, 1998 to address these areas (CDPHE 2015a).

The report *Characterization of Areas of Elevated Radioactivity Levels, The Windblown Area*, submitted on June 24, 2003, details the results of exposure surveys conducted in 1998 and 2000. Several areas were identified with exposure rates greater than 30 µR/hr. These areas were further inspected to determine whether they were impacted by mill-related deposits or mine-related/ore outcrops. In most cases these areas were determined to be either mine-related/ore outcrops. The report identified very thin windblown deposits north of Tailings Piles 1 and 2, but because these deposits were thin and within the area described by Section 4.7.2.4 of the RAP, no additional cleanup was required or performed. The report identified two elevated areas containing mill-related material: Area E due to windblown material, and Area J due to mill tailings slimes (CDPHE 2015a).

CDPHE requested further evaluation of Area E and on September 1, 2006, Umetco submitted a report titled *An Evaluation of Area E in the Windblown Area*. The report concluded that average radionuclides and heavy metals present in Area E, although elevated, did not exceed RAP cleanup standards. Average exposure rates (average 34 µR/hr) for Area E were found to have similar exposure rates to bordering areas (D and G) with naturally occurring radioactive material (NORM) attributed exposure rates of 36 to 46 µR/hr (Umetco 2006a). Therefore, no further additional remedial action was proposed. CDPHE concurred with the finding by letter dated October 12, 2006 (CDPHE 2015a).

During 2000, mill tailings slimes were removed from Area J. These materials (approximately 2,700 cubic yards) were removed by vacuum truck and hand excavated to the extent practicable, given the extremely steep and dangerous slopes. During 2002, approximately 3,700 cubic yards of contaminated soils were removed above Sedimentation Basin 9 and from an area between Tailings Piles 1 and 2 and the Bone Yard, sometimes known as the North 40. Although no discrete deposits of windblown material were identified by the characterization survey, a few contaminated areas along the haul road in the North 40 were remediated. In 2003, an additional 9,000 cubic yards of contaminated soils were removed from these areas. These cleanup activities are documented in Compliance Report CR-418B-2. An additional radiological survey of this area

was performed and submitted at Compliance Report CR-418B-3. During 2014, approximately 300 cubic yards of mill tailings slimes were removed from a small area within Area J. These materials were removed by hand excavation to the extent practicable, given the extremely steep and dangerous slopes and sent to the Energy Solutions site in Clive, Utah (CDPHE 2015a).

Final reclamation activities were performed between May and July 2003 in accordance with the Final Grading and Drainage Plan dated February 22, 2002. The mine adits were backfilled with random fill. Areas in front of the adits were graded to blend with the existing slope using rock mulch and two-foot minus rock rubble. Permanent drainage diversion channels were constructed in the locations of the former ponds (CRP-5, CRP-6, and SB-9). The reclamation work is described in Compliance Report CR-418B-4 (CDPHE 2015a).

4.1.7.4 Mill Hillside

The Mill Hillside was located within the Uravan restricted area and includes steep terrain extending from near the base of the colluvial slope in the former A-Plant area to the top of the Club Mesa rim and from the mouth of Hieroglyphic Canyon to the northwest for about 4,000 feet. A characterization investigation was conducted in 1998 to determine the depth and areal extent of contaminants in accordance with the *Characterization Investigation Plan for Surface and Subsurface Soils at the Mill Hillside, Water Storage Ponds, and County Road EE-22*, dated August 19, 1998 and approved by CDPHE on September 10, 1998. The objective of this investigation was to characterize radionuclide contamination on the surface of remnant mill area foundation structures. The results were detailed in the *Characterization Report and Remedial Action Plan for the Mill Hillside*, revised on April 14, 1999. The characterization activities were also reported in Compliance Report CR-418C-1. Approximately 40 percent of the hillside could not be characterized due to the presence of steep slopes and dense vegetation, precluding safe access. However, it was determined that sufficient data were gathered to assess project area conditions using historic information and to develop appropriate remedial actions (CDPHE 2015a).

Remedial activities were initiated in 1999 with the focus on the demolition and removal of concrete foundations and structures associated with the former uranium/vanadium mill. Over 7,000 cubic yards of sized concrete debris and contaminated soils were taken to the B-Plant Repository. CDPHE's Uravan On-Scene Coordinator inspected the cleanup activities and recommended that discrete deposits of contaminated material be removed. This resulted in approximately 23,000 cubic yards of contaminated materials removed in 2001 and 2002 and placed in the B-Plant Repository and Tailings Piles 1 and 2. This additional remediation was also conducted to establish terraces to reduce erosion and enhance the hillside seepage collection system. These activities were described in Compliance Report CR-418C-2 (CDPHE 2015a).

A confirmation investigation was conducted between 1999 and 2002 after removal of contaminated material, including exposure rate measurements, assays for surface and subsurface soils, and a risk assessment. The results were detailed in the *Confirmation Investigation Report, Mill Hillside, Uravan, Colorado*, submitted in December 2002 as Compliance Report CR-418C-3. These reports were approved by CDPHE in February 2003. The confirmation investigation concluded that, in general, all contaminated materials physically and safely accessible were removed from the hillside; however, final verification measurements indicated elevated concentrations of residual contaminated material on some of the steeper inaccessible sloped areas.

Alternate Soils Standards were requested for this area in the Alternative Soils Standards Application (Umetco 2007a). An average exposure rate of 45.4 µR/hr was measured for the area with a maximum exposure of 202 µR/hr for a single 10-by-10-meter grid. Average Ra-226 concentrations were measured to be 22 pCi/g with a maximum exposure of 173 pCi/g for a single 10-by-10-meter grid. Confirmation soil sampling measured average Ra-226 concentrations to be 17.1 pCi/g for surface samples and 10.5 pCi/g for subsurface (15-30 cm) samples. NORMs were noted on the mill hillside. Based on a risk assessment performed for the area, maximum human exposure would occur for a hunter-hiker using the area and ingesting meat from an animal harvested in the area. The annual radiation dose to such a hiker would be 4.6 mrem, below a 25 mrem per year public radiation dose standard. Alternative standards were proposed for the following reasons:

- The steep hillsides posed a risk of injury to construction workers during potential additional remediation.
- Remedial actions could result in destabilization of the slope and release of sediment to drainages (and ultimately the San Miguel river), causing excessive harm to the environment.
- No habitable structures would be constructed in the area because of future IC and stewardship of the land by the DOE.
- Cost of remediation would be excessive in relation to small decrease in human exposure.
- Previous remediation actions reduced exposures to ALARA.
- Future land use would be habitat for wildlife and not for residential or related structures. The DOE will assume long-term stewardship of the property and manage land use.

The general (accessible) hillside area was stabilized with a nominal 3-foot thickness of 2-foot diameter minus rock rubble to prevent sediment migration in 2003. The final reclamation, including grading and drainage activities, was conducted in 2003 in accordance with the *Design Change Order, Final Reclamation Grading for the B-Plant Mill/Bone Yard areas, Mill Hillside Area and the A-Plant Mill Area*, dated September 20, 2002, and approved by CDPHE. These activities also included the removal of the concrete seepage collection system. The reclamation work was described in Compliance Report CR-418C-4 (CDPHE 2015a).

4.1.7.5 County Road Y-11

The County Road Y-11 area is located along the southwest side of San Miguel River. The road in the vicinity of the Town Dump was remediated during the cleanup activities at the Town Dump between March 1998 and December 2000.

Umetco conducted a characterization investigation on the portion of County Road Y-11 from the new bridge over the San Miguel River to the Town Dump between June 1996 and April 1997 in accordance with the *Remedial Investigation Plan for County Road Y-11* dated May 1996. Gamma exposure rates and radionuclide and metal concentrations were measured above average regional background levels in and beside an approximately 5800-ft portion of the road between the County Road Y-11 Bridge and the old Iron Bridge adjacent to the Town Dump. The roadbed is

composed of natural earthen materials, NORM in the form of overburden, waste rocks, and tailings. Contaminated soils were found to exist at depths greater than 3 feet beneath the roadway. Remediation of the road was not considered practical because of lack of access. As a result of this and the elevated readings, a risk assessment was prepared for this portion of the road (CDPHE 2015a).

The Risk Assessment determined that the excess radiation doses received by an individual along the surveyed portion of County Road Y-11 would be less than 10 percent of the decommissioning dose limit of 25 mrem per year (MFG, Inc. [MFG] 2004). The final Risk Assessment, including response to CDPHE comments and an ALARA analysis, was submitted in May 2004. CDPHE approved the Risk Assessment on December 8, 2005. The characterization investigation and ensuing risk assessment activities were addressed in Compliance Report CR-418D-1 (CDPHE 2015a).

In September 2006, Montrose County Engineering approved plans to perform prescriptive remediation work on the road between the new County Bridge and Old Iron Bridge (Black Bridge) (road segment Y11-400) and between the Hieroglyphic Canyon Bridge and the Historic Community Center Building (road segment Y11-800). In September 2006, approximately 8,200 cubic yards of visible tailings were removed from several locations along these road sections and placed in the B-Plant Repository. The discrete excavations were in the roadway and extended into the shoulders either through the drainage ditches on the hill side of the road or out towards the riverbank as necessary to remove all visible tailings. Excavation depths, up to 11 feet deep in places, were determined by real time scintillometer surveys. After excavation, the roads were backfilled and reestablished. The reclamation activities were addressed in Compliance Report CR-418D-2 (CDPHE 2015a).

Radiological surveys of the roadway were performed in February and April 2007, and reported in CR-418D-2. The results indicated that the removal of the discrete visible tailings had reduced the average radium-226 concentration to 4.5 pCi/g, below the RAP guideline of 7.1 pCi/g. However, some areas with radium-226 concentrations over 7.1 pCi/g remain and are located approximately 1,000 feet west of the intersection of County Road Y-11 with County Road V-18. The County Road Y-11 roadway and right-of-way were included in the Alternative Soil Standards Applications for the following reasons:

- Potential health risks were considered negligible as contaminated material were only present at depths greater than 3 feet, and future exposures will be minimized by ICs.
- Cost of remediation would be excessive in relation to small decrease in human exposure.
- Previous remediation actions reduced exposures to ALARA.
- Future land use would be as a road and not for residential or related structures. The DOE would assume long-term stewardship of the property and manage land use.

4.1.7.6 County Road EE-22

The County Road EE-22 project area includes the roadway from the San Miguel River to the top of the Club Mesa. It was mainly used to provide access to the numerous uranium, radium, and vanadium mines located on the mesa. Radiological anomalies were highly probable due to the

presence of ores along the side of the road. Soil contamination also included uranium tailings from past mill operations at Uravan (CDPHE 2015a).

A characterization investigation was conducted in 1998 in accordance with the *Characterization Investigation Plan for Surface and Subsurface Soils at the Mill Hillside, Water Storage Ponds, and County Road EE-22* dated August 1998. The objective of the characterization investigation was to provide radiological, radiochemical, and inorganic data for surface and subsurface soils. Gamma surveys were also conducted. Results of the investigation were submitted in the *Characterization Report and Remedial Action Plan for Montrose County Road EE-22* in December 1998. The characterization investigation was documented in Compliance Report CR-418E-1 (CDPHE 2015a).

Based on the results of the characterization investigation, remedial action plans for this area were developed. In 2000, approximately 1,730 cubic yards of visible slimes were removed from the hillside above the road and placed in the B-Plant Repository. In April 2001, approximately 4,500 cubic yards of visible tailings and contaminated soils were removed from beneath a 500-foot section of the roadway and right-of-way. These materials were placed in the B-Plant Repository. Upon completion of the cleanup activities, the area was inspected and approved by the CDPHE On-Site Coordinator. An additional 88 cubic yards of contaminated material was removed in April 2002 after it was identified during the field inspection by CDPHE. The remedial activities were documented in Compliance Reports CR-418E-2 and CR-418E-3 (CDPHE 2015a).

Backfilling and regrading activities took place in April and May 2001. Approximately 5,744 cubic yards of clean random fill from the Club Mesa borrow area was used to backfill the road. After the roadway was reestablished, it was surfaced with a 6-inch layer of Class 6 roadbase. The final reclamation activities were documented in Compliance Report CR-418E-4 (CDPHE 2015a).

Confirmation Investigation Report, Montrose County Road EE-22, Uravan, Colorado was submitted in December 2002 as Compliance Report CR-418E-3. The report indicates remedial action was successful in removing uranium mill tailings from the roadway. The average exposure rate is below the 30 µR/hr standard specified in Section 4.7.2.4.1 of the RAP. The average concentration of radium-226 in surface soil from scintillometer survey data met the RAP criteria; however, the average radium-226 and thorium-230 results from laboratory analyses for surface soil samples were above Category 1 and Category 2 soil cleanup values but less than risk-based Category 3 values (CDPHE 2015a).

Because of elevated radium and thorium readings along the roadway, Umetco recommended the county road be paved so potential future exposures are maintained ALARA. Paving the roadway would ensure mitigation of possible dust generation and further reduce potential exposures to humans (CDPHE 2015a).

4.1.7.7 Water Storage Ponds

The Water Storage Ponds project area is located outside the Uravan restricted area, west of the San Miguel River and County Road EE-22, and bounded on the east by Hieroglyphic Canyon. This area consisted of the pond embankments and two former ponds with dimensions approximately 500 feet long by 200 feet wide. The ponds were dry for 10 to 15 years before remediation. This area was one of the areas of dispersed deposits at Uravan (CDPHE 2015a).

A characterization investigation was conducted in 1998 to determine the depth and areal extent of contamination. The investigation was performed in accordance with the Characterization Investigation Plan for Surface and Subsurface Soils at the Mill Hillside, Water Storage Ponds, and County Road EE-22 and approved by CDPHE on September 10, 1998. The investigation provided data for radiological, radiochemical, and inorganic constituents of concern in surface and subsurface soils. Based on the characterization investigation, remedial actions were developed, and the resultant Characterization Report and Remedial Action Plan for the Water Storage Ponds was submitted on December 3, 1998 and approved by CDPHE on June 15, 1999. This activity was reported in Compliance Report CR-418F-1 approved by CDPHE on May 9, 2002 (CDPHE 2015a).

Cleanup activities occurred in March and April 1999, with the removal of approximately 17,500 cubic yards of contaminated soils. The depth and extent of excavation was controlled and monitored by real-time gamma scintillation measurements. The excavated soils were placed in Tailings Piles 1 and 2 and the B-Plant Repository. This work was detailed in Compliance Report CR-418F-2 and CR-418F-3 (CDPHE 2015a).

Confirmation surveys and soil sampling were performed during 1999 and 2000. The *Confirmation Investigation Report, Water Storage Ponds* was submitted in January 2000. The report indicated that the contaminant concentrations were reduced to levels below the corresponding remedial action plan objectives given in the 1999 Site-Specific Soil Cleanup Objectives Rational Document, below the NRC license termination criteria (NRC 1999), and to levels below typical EPA CERCLA requirements. Therefore, the site was proposed to be released for unrestricted use. The confirmation activities were documented in Compliance Report CR-418F-3 (CDPHE 2015a).

A final grading plan, included in the confirmation investigation report, was established and required the placement of a minimum of 6 inches of stable fill in the area of the highest residual contaminant concentrations to provide for the appropriate application of subsurface RAP objectives and minimize potential future exposures to individuals. Final grading activities were conducted in May 2000. The steep slopes within the excavated area were graded and contoured to blend with the existing slopes and drain towards Hieroglyphic Canyon. Depressions were backfilled and a minimum of 6 inches of soil was placed in the required areas. Revegetation activities were performed during November 2000. This work was documented in Compliance Report CR-418F-4 (CDPHE 2015a).

4.1.7.8 Atkinson Creek Drainage Way

Atkinson Creek enters the San Miguel River from the north, approximately 3 miles west-northwest of Uravan. The creek is an intermittent stream and provides drainage from much of Atkinson and Spring Creek Mesas (CDPHE 2015a).

A characterization scintillometer survey was conducted in May 1990. No readings greater than 20 µR/hr were observed along the streambed and therefore no remedial activities were required. A confirmation scintillometer and soil sampling survey were conducted on December 17, 1992, which also indicated no readings over 20 µR/hr. Radionuclide and metal concentrations in the soil samples were all below background levels. The results of both surveys were submitted to CDPHE on December 28, 1992, and were also detailed in the Characterization Investigation Report and Remedial Action Plan for Atkinson Creek Streambed, Uravan, Colorado, dated May 5,

1994. These activities were documented in Compliance Report CR-418H-1, approved by CDPHE on February 19, 2002 (CDPHE 2015a).

4.1.7.9 Hieroglyphic Canyon Drainage Way

Exposure measurements were collected within the stream channel of Hieroglyphic Canyon in May 1990, to characterize the extent of contamination. Two additional surveys were conducted in June 1994. The first survey was completed in the upper portion of the canyon, upstream of the area covered by the 1990 survey, and was conducted to establish mining-related effects. The second survey covered a portion of the 1990 survey area and was conducted as a veracity check. The results of the characterization surveys are detailed in *Technical Assessment of the Hieroglyphic Canyon Streambed, Uravan, Colorado*, which was submitted in December 1994. The report concluded that mechanized soil removal would be costly and result in significant disturbance to the environment, and that the impacts of contaminant release to the river would not cause exceedance of radionuclide concentration limits in the San Miguel River. Therefore, a no-action alternative was proposed. However, the report stated that discrete deposits of contaminated materials would be remediated where accessible. In the approval letter dated April 6, 1995, CDPHE agreed to limit the remediation activities to the removal of accessible mill-related contamination within the stream channel and the radioactive hot spots on the canyon slopes. In this letter, CDPHE also requested a Materials Identification and Removal Plan. The plan was submitted on August 17, 1995, and stated that contaminated material would be removed from the canyon mouth to an area upstream where movement of materials and equipment would be restricted. In addition, to assure that stream sediments continue to meet appropriate standards, contaminated soils would also be removed from the area known as Treasure Island and from the rim of Club Mesa (CDPHE 2015a).

Cleanup activities took place in 1991 and 1994 at the replacement location of the County Bridge and along the rim of the canyon, respectively. Additional cleanup work was performed between June 1998 and February 1999 with the removal of contaminated soils from the mouth of Hieroglyphic Canyon and the Treasure Island area. Additional cleanup was conducted in August and September 2000. These activities are documented in Compliance Report CR-418I-1 (CDPHE 2015a).

4.1.7.10 Northeast Side of Colorado Highway 141

Northeast side of Colorado Highway 141 encompasses approximately 7 acres of land along the northeast side of the 0.5-mile highway in San Miguel River valley. The characterization survey of the area was conducted in 1996 under a CDOT survey permit and in accordance with the *Remedial Investigation Plan for Surface and Subsurface Soils and Structures, Northeast of Highway 141, Uravan, Colorado, Revision 1,* dated March 1996. The investigation provided data for radiological, radiochemical, and inorganic constituents in the surface and subsurface soils and structures. The results were detailed in the *Characterization Report and Remedial Action Plan for the Surface and Subsurface Soils and Structures, Northeast of Highway 141*, revised April 2000. The characterization activities were detailed in Compliance Report CR-418J-1 (CDPHE 2015a).

The characterization investigation identified contaminated materials in the specific areas along the northeast side of the highway. These areas included the liquid impoundment (Frog Pond), the transformer substation area, the explosive magazine, the mouth of Red Canyon, the G-Block Well House, the F-Block Electrical Storage Building and the F-Block Pump House, but not the highway

itself. BLM gave approval to remove contaminated material located on BLM property on February 23, 1999. Based on the characterization investigation, approximately 25,400 cubic yards of contaminated soils, debris and structures were removed and placed in the B-Plant Repository in 2000. These activities were detailed in Compliance Report CR-418J-2 (CDPHE 2015a).

The RAP stipulated that Umetco was responsible for the removal of contaminated soils from beneath the highway whenever they are exposed but only while the Tailings Piles are open. The CDOT was informed of this, but declined to have any contaminated materials removed from beneath the highway as noted in the CDOT construction permit issued on March 13, 2000, for the work within the right-of-way (CDPHE 2015a).

Confirmation surveys were performed in 2000 and detailed in the Confirmation Report, Northeast of Highway 141, dated December 21, 2002, and approved by CDPHE on January 14, 2003. The report indicated that the average exposure rate is below the RAP guideline of 20 μR/hr. Surface and subsurface soil concentrations of radionuclides and heavy metals are below the Category 2 cleanup objectives. Radium concentrations in four surface soil samples exceed the Category 2 surface soil cleanup objectives. All radium concentrations in the subsurface soil samples met the Category 1 soil cleanup objectives. The report concluded no additional remedial actions were warranted in the Highway 141 project area outside of the highway right-of-way. This work segment was addressed in Compliance Report CR-418J-3 (CDPHE 2015a).

Final reclamation was conducted in 2000, including backfilling, regrading, erosion protection, and revegetating the disturbed areas. Approximately 7,900 cubic yards of random fill were used as backfill. All disturbed areas were graded to blend with the surrounding topography and provide, as far as practicable, the original drainage features. Riprap was placed in the channel at the mouth of Red Canyon as erosion/scour control. Revegetation activities were performed during November 2000 in accordance with the Revegetation Specifications. The reclamation activities were detailed in Compliance Report CR-418J-4 (CDPHE 2015a).

The CDOT Highway 141 remedial action area encompasses about 1 mile of land in the right-of-way corridor in the San Miguel River Valley. This removal action occurred in 2006 and resulted in excavation of 51,000 cubic yards of material being disposed of in the B-Plant Repository. Following the remedial action, on September 4, 2007, approximately 7 acres comprising a one-mile section of Highway 141 between mile posts 75 and 76 was deleted from the NPL.

4.1.7.11 The Nature Conservancy Visitor's Site

Elevated radiation levels in soil were observed in an open parcel of land located southeast of the Uravan Ball Park, approximately one mile from the town center. A portion of the approximately 7.5-acre site belongs to Umetco and the remainder belongs to the Nature Conservancy. The site is collectively referred to as the Nature Conservancy Visitor's Site (NCVS). Umetco conducted investigations of the NCVS in 1997 and performed remedial activities in 1998 (Umetco 1999c). The site was not included in the RAP; a separate remedial action plan was developed for the NCVS.

Approximately 4,800 cubic yards of contaminated soil were removed from September to November of 1998 and disposed of in the Uravan B-Plant repository. Groundwater was encountered in two areas adjacent to the San Miguel river during excavation. Excavation did not

continue below the groundwater table. A soil cover was installed in accordance to the final grading plan at the NCVS.

4.1.7.12 Other Town Areas

Several other areas of the former town are reported by Umetco to be below contaminant background levels (Umetco 2015) and were therefore not a part of the RAP cleanup efforts. These town areas include the E Block, F Block, Corrals, Gym Area, Ball Park, and Homer Woods. Additional information on these areas was not reviewed as a part of this report preparation.

4.1.8 Burbank Quarry

The Burbank Quarry was originally intended to be the source of riprap for remedial activities. Fill and clays were mined from the quarry pit for use in remedial construction (E2 2010). The quarry area was divided into two repositories. The lower Burbank Quarry was used for disposal of raffinate crystals originating from the Site. The upper Burbank Quarry was used as a Title I Repository by the DOE for disposal of waste material from the nearby Naturita processing site (CDPHE 2015a).

In the RAP, as amended, CDPHE selected a remedy that placed the raffinate crystals removed from the Atkinson Creek Crystal Disposal Area, the CRPs and the Club Mesa Spray Area in below-grade Burbank Quarry locations. Raffinate crystals were to be dispersed in clay-lined cells that would be capped by earthen materials and riprapped for erosion control and protection. Umetco designed the Burbank Quarry cap systems in consideration of the probable maximum precipitation events and maximum credible earthquakes (E2 2010).

Umetco began placement of the raffinate crystals into the lower Burbank Quarry in 1989 and completed the work in 1992. Umetco capped the raffinate crystals with an earthen cover in accordance with the RAP; the side slope was completed in 1993; the toe drain was installed in 1998; and the top cover was completed in 1999 with the placement of cover of riprap rock. The Burbank Quarry – Uravan UMTRCA Title II activity was completed by 2000 (E2 2010).

DOE used the upper portion of the Burbank Quarry Repository for disposing Title I radioactive materials from the Naturita processing site. Approximately 600,000 cubic yards of radioactive materials were placed in the Burbank Quarry repository. A multilayered cover, identical to the Uravan Tailings Piles covers, was constructed on top of the placed contaminated materials. Permanent drainage diversion structures and control features were constructed for storm water management to and from the repository. The Burbank Quarry Repository – DOE UMTRCA Title I activity was completed in 1998 (E2 2010).

4.1.9 Borrow Areas on Club Mesa

The Borrow Areas on Club Mesa were not contaminated and were used as sources of the clayey soils and random backfill to be used during remedial activities. The Club Mesa Borrow Area is operated pursuant to the requirement of a Mine Land Reclamation permit issued by the Colorado Department of Natural Resources, Division of Minerals and Geology (E2 2010).

Remediation activities at these areas were not conducted. This area was the intended resource for clayey soils and backfill to be used in remedial activities. Final mine land reclamation will be accomplished pursuant to the requirements established by the issuance of the Borrow Area Mine Land Reclamation Permit (EPA 2015).

Three borrow areas exist for the Site. Two (Elk and Surprise Borrow areas) are located on Club Mesa, with one above the Burbank Repository. The third is located in the San Miguel River Valley on the east side of Colorado Highway 141, across from the Club Ranch Ponds. The borrow areas on Club Mesa, which includes the Kaiser Quarry, were expanded in 1992, 1997, 2002, and 2003 (E2 2010).

The Kaiser Quarry produces sandstone suitable for erosion protection materials. The Kaiser Quarry is located west of the Club Mesa Area within Umetco's patented Kaiser Claim Boundary. All the borrow areas are operated in compliance with the Mine Land Reclamation Permits (EPA 2015).

4.2 Liquids

The RAP also described five liquid remedial activities: hillside seepage and tailings liquids, ponded liquids, surface runoff and groundwater.

4.2.1 Hillside Seepage and Tailings Liquids

Seepage had been occurring intermittently along approximately 4,600 linear feet of the Club Mesa rim. Seepage occurred near the contact between the Summerville and Salt Wash Formations and exits the valley walls of Hieroglyphic Canyon and the San Miguel River above the A-Plant Area. The seepage was composed of geochemically modified tailings solutions from the Club Mesa Tailings Piles and the Club Mesa Spray Area (EPA 2015).

The dewatering and consolidation process forced liquids from the Club Mesa Tailings Piles during dewatering and consolidation and for some time prior to and after final reclamation activities. Seepage was collected by toe drain system at the base of the slopes of the Club Mesa Tailings Piles and conveyed to the CRPs with the Hillside Seepage Collections System liquids (EPA 2015).

Sections 5.1.1.2 and 5.1.2.2 of the RAP required the following construction activities to ensure adequate remediation of the Hillside Seepage and Tailings Liquids.

- Improve and line the existing collection system.
- Construct a lined collection system at the base of the Entrada Formation to collect surface flow and seepage.
- Construct trenches and sumps to enhance dewatering and consolidation of tailings in the repositories.
- Collect and dispose of contaminated liquids until there are no flows for 3 consecutive years in any collection system segment or contaminant concentrations meet water quality objectives.
- Dispose of collected liquids in the new lined Club Ranch Ponds (CDPHE 2015a).

Improvements to the existing hillside seepage collection system started in August 1988 and continued until completion in December 1988. Work included the following: cleaning; regrading and lining the main ditch; cleaning, enlarging and lining the three diversion ponds; installation of two culverts, and; patching and widening other ditches. This work is detailed in Compliance Report CR-426-1, dated April 1989 (CDPHE 2015a).

Construction of the new Subgrade Collection System drains at the base of the Entrada Formation was started after preliminary grading of the hillside seepage collection system in August 1988. The system consisted of several lined drains that were completed in accordance with the plans. Drains were not constructed if the excavations were dry and were extended if the excavations indicated a greater seep area. Energy dissipater was not required because of extremely low fluid velocity. A pump back system was constructed to return collected fluids to the new Club Ranch Ponds. The system was operational in December 1988 as required by the RAP. The construction work and changes to the Subgrade Collection System were noted in Compliance Report CR-426-2 (CDPHE 2015a).

The construction of trenches and sumps for the toe berm seepage collection system to enhance surface dewatering and maintenance on the Tailings Piles began in January 1988 with the upgrading of the existing toe drains with concrete sumps and double pipelines. Between June and November 1988, the collection system was extended to intercept seepage detected along the southeast end of the Bone Yard below the toe of Tailings Piles 1 and 2. The toe drain extension routed the seepage towards the sumps. This work segment is detailed in Compliance Report CR-426-5, dated March 2003 (CDPHE 2015a).

During 2000, Umetco drilled 17 borings into the mine workings on Club Mesa for the purpose of evaluating and managing contained contaminated liquids, of which five were selected for pumping and conveyance of mine workings liquid. Umetco extracted and transferred the raffinate solution in the mine workings to the Club Ranch Ponds for evaporation. Approximately 500,000 gallons of raffinate contaminated liquid was pumped from the mine workings during 2000 and 2001. Umetco has not reported any additional liquids extracted from the Club Mesa Area mine workings since the fourth quarter of 2001 (EPA 2015).

Umetco submitted *Technical Evaluation of Mill Hillside Seepage: Uravan, Colorado* on September 4, 2002. The analysis concluded that seepage flow volumes would continue to decline and that the water quality of the seepage would not impact the San Miguel River water quality even during low river flow conditions. CDPHE approved the report on September 24, 2002, and stated that the collection of hillside seepage was no longer required and allowed for the Hillside Seepage Collection System decommissioning in April 2003. All liners, hardware and contaminated soils were removed and placed in the B-Plant Repository. Details of this work are given in Compliance Report CR-426-3, dated April 30, 2003, and were approved by CDPHE (CDPHE 2015a).

A Design Change Order for final grading activities in the Mill Area, including the areas used for the Hillside Seepage Collection System, was submitted to CDPHE on September 27, 2002. The approved plan included the removal of concrete from the ditches and diversion ponds and the placement of rock rubble to provide erosion protection. Placement of rock rubble began on May 2003 after the concrete within the ditches and ponds had been removed. Reclamation activities

were completed in June 2003 and are documented in Compliance Report CR-426-4, dated June 2005 (CDPHE 2015a).

4.2.2 Ponded Liquids and Surface Runoff

Contaminated liquids were contained in various ponds around the mill and within the mill circuit. The liquid in the Club Ranch Ponds consisted of toe drain and hillside seepage, collected since mid-1985, and raffinate solution from discharges to the ponds prior to 1984. These liquids along with those in the River Ponds and Club Mesa Storage Ponds seeped into the subsurface below these unlined ponds. The RAP required these liquids to be placed into lined ponds (CDPHE 2015a).

Sections 5.2.1.2, 5.2.2.2, and 5.3.2 of the RAP required the following construction activities to ensure adequate remediation of the Ponded Liquids and Surface Runoff:

- Evaporate all liquid waste in the existing unlined Club Ranch Ponds.
- Transfer all liquids in the River Ponds, Storage Ponds on Club Mesa, and within the Mill Circuit to the Club Ranch Ponds.
- Construct and operate the surface runoff collection and sedimentation pond system until all remedial activities are complete (CDPHE 2015a).

By May 31, 1988, all collected fluids from mill circuit, hillside seepage and toe berm collection systems, and the surface runoff collection systems were being pumped into the new lined evaporation pond, CRP-7. Verification of this work was detailed in Compliance Report CR-429-1, approved by CDPHE on June 14, 1988 (CDPHE 2015a).

Dewatering of the existing Club Ranch Ponds began as soon as all the site wide liquids were transferred to CRP-7 on May 31, 1988. Only internal flows between the existing Club Ranch Ponds were authorized to enhance the surface area for evaporation. By December 24, 1988, the remaining liquids were pumped to new lined evaporation ponds. The existing ponds were drained and approximately 11.4 million gallons were transferred by the deadline date given in the RAP. The dewatering activities are detailed in Compliance Report CR-401-2, approved by CDPHE on April 20, 1989 (CDPHE 2015a).

By letter dated December 11, 1987 and reconfirmed on April 11, 1989, Umetco notified CDPHE that the River Ponds and the Storage Ponds on Club Mesa were empty. On May 2, 1989, CDPHE indicated that since the ponds were empty and no longer existed, Umetco would no longer be required to submit reports on the status of the ponds (CDPHE 2015a).

On April 13, 1998, Umetco informed CDPHE that they had been contacted by MK-Ferguson Company, the construction contractor for the DOE's Title I Naturita Project, to request permission to dispose of contaminated water stored in the Title I lined retention basins at the Title I Upper Burbank Disposal Cell. Umetco requested these liquids be transferred to the lined Club Ranch Ponds. CDPHE authorized acceptance on April 14, 1998 (CDPHE 2015a).

A Field Change Order was submitted on August 17, 1998, for approval to relocate four Runoff Control Ponds in the A-Plant area to facilitate contaminated soils removal and to construct a new return water pond in the B-Plant area. The ponds were constructed by March 1999 (CDPHE 2015a).

On Apri1 30, 2003, Umetco notified CDPHE that the remediation of all waste material was complete and the placement of the reclamation covers on the Tailings Piles was complete. Since there were no longer exposed contaminated soils, Umetco requested all the runoff control ponds be decommissioned. CDPHE approved the pond decommissioning on May 20, 2003. All the runoff control ponds were removed during the second quarter of 2003. This activity is detailed in Compliance Report CR-429-2, dated October 2005 (CDPHE 2015a).

4.2.3 Groundwater

Seepage from the Uravan Mill operations and waste disposal infiltrated into the Salt Wash and created a body of perched fluids on Club Mesa. This infiltration primarily consisted of raffinate from the Club Mesa Spray Area and seepage from the Club Mesa Tailings Piles. Hydrologic monitoring wells constructed in the Salt Wash indicate the areal extent of the fluids is in the area beneath and down gradient from the three Club Mesa Tailings Piles and spray evaporation area. Groundwater flows to the northeast toward the west and south San Miguel River Valley walls and to the walls of Hieroglyphic Canyon. Perched liquids on top of the Summerville Formation have dispersed and no significant seepage has been noted along the canyon valley walls (E2 2010).

Umetco's past operations on Club Mesa and past waste disposal activities potentially impact the groundwater quality in the Kayenta-Wingate aquifer beneath Club Mesa. Past activities that could potentially impact the aquifer were the use of the Club Mesa Spray Area and Club Mesa Tailings Piles. These activities have ceased. The low permeability of the Summerville shale formation above the Kayenta-Wingate aquifer prevents significant contaminant transport down to the Kayenta-Wingate aquifer. In 1986, Umetco drilled groundwater monitoring wells V-768 and V-769 into the Kayenta-Wingate Formation beneath the Club Mesa (E2 2010). Samples taken from the Club Mesa wells drilled down to the Kayenta and Wingate Formations showed no significant contamination from the milling operations.

In 1993, three additional groundwater monitoring wells (CM93-1, CM93-2, and CM93-3) were installed on Club Mesa, at CDPHE's request, for further testing and monitoring of the Kayenta-Wingate aquifer and provide additional permeability data for the Summerville Formation. CM93-1 and CM93-2 are hydraulically up-gradient of the Tailings Piles and Spray Area; while the CM93-3 is hydraulically down-gradient of these areas. The results of the testing concluded that the Summerville and Kayenta had very low permeabilities while the Salt Wash had much higher permeabilities (CDPHE 2015b).

A summary of the results of groundwater monitoring and permeability testing through 1993 were detailed in Hydrogeology of Club Mesa, Uravan, Colorado, submitted on March 4, 1994. The water quality data in this report showed that the aquifer had not been affected by raffinate or tailings solutions and that the Summerville aquitard stopped these solutions from reaching the aquifer (CDPHE 2015b).

In March 1998, DOE presented a groundwater hydrology report, attached as Appendix B of the report entitled Remedial Action Plan and Site Design for Stabilization of the Naturita Title I Residual Radioactive Materials at the Upper Burbank Repository, Uravan, Colorado. The Upper Burbank Repository is now DOE's UMTRCA Title I Naturita Disposal Site, and is located adjacent to and up-gradient of the Club Mesa Spray Area and the Tailings Piles; therefore, the groundwater hydrology presented in this report is also representing the Club Mesa area. This report indicated that the travel time needed for the contaminated fluids from the bottom of the repository to infiltrate through the Salt Wash Member and the Summerville Formation are 130 and 900 years, respectively. This means that it would take over 1000 years for any contamination fluid in the repositories on the Club Mesa to reach the Kayenta-Wingate aquifer and discharge to the San Miguel River (CDPHE 2015b).

On December 6, 1999, CDPHE approved the use of monitoring well CM93-3 as the Point of Compliance well for Club Mesa repositories because it was hydraulically down-gradient of the repositories and would allow for early detection of any contamination from the repositories. CDPHE also reviewed the historic differences in water chemistry between the groundwater from the Paradox Valley and the groundwater adjacent to the San Miguel River. On March 29, 2001, CDPHE approved Umetco's proposal on the background concentrations and concentration limits for CM93-3. The concentration limits were chosen to be the larger values of the background concentrations and the EPA's drinking water standards. The concentration limits were then used to evaluate the groundwater quality in this well for raffinate-derived constituents. In addition, a time-sequence trilinear plot was also used to evaluate the change in the calcium-magnesium ratio of these constituents (CDPHE 2015b).

In December 2006, Umetco informed CDPHE that groundwater monitoring at CM93-3 between 1993 and 2006 had not shown any mill-related contaminants in the Kayenta-Wingate aquifer and this aquifer has not been contaminated over the 50 years since the use of the Spray Area and the Tailings Piles. This is consistent with previous studies showing that the 90-foot thick Summerville aquitard effectively isolates the water resources in the Kayenta-Wingate aquifer. This is also consistent with the 1998 DOE groundwater hydrology report concluding that the travel time to the aquifer from the repositories on Club Mesa would be greater than 1000 years. In addition, Umetco stated that the presence of CM93-3 may pose a problem in the future since it may allow a pathway for contaminants to reach the Kayenta-Wingate aquifer, in the case of any deterioration or failure of this well. Therefore, Umetco requested the abandonment of this well (CDPHE 2015b).

Both CDPHE and DOE reviewed Umetco's request for CM93-3 abandonment and agreed with Umetco's assessment. DOE further considered that accessing this well for future rehabilitation or abandonment may become a concern as the Site roads are remediated and removed. In addition, CDPHE considered that the Tailings Piles have been consolidated with covers constructed with drainages and will not contain enough water to produce any significant amount of seepage to the subsurface. Even if seepage were to occur from the Tailings Piles, it is likely to flow toward the hillside and surface on the cliff face as historically shown rather than infiltrating into the Kayenta-Wingate aquifer due to the Summerville aquitard. Even if the seepage were to infiltrate into the aquifer, any wells on the Club Mesa to monitor the groundwater in the Kayenta-Wingate aquifer will not be able to identify the contamination as the travel time from the repositories to the aquifer is greater than 1,000 years. CDPHE also considered that the Kayenta-Wingate aquifer

discharges to the San Miguel River, and the approved long-term groundwater monitoring program, including the State ACL of groundwater and monitoring wells, in the San Miguel River Valley, is effective to protect the water quality in the San Miguel River. Therefore, both CDPHE and DOE did not find a need for this well to be included in the long-term monitoring program. CDPHE approved the abandonment of CM93-3 on March 19, 2008 with concurrence from DOE on May 5, 2008, and determined that no further remedial activities will be needed for Kayenta-Wingate aquifer on Club Mesa (CDPHE 2015b).

CM93-1 and CM93-2 were transferred to DOE as the monitoring wells for the DOE Title I Naturita Disposal Site. On April 15, 2014, NRC approved the termination of the groundwater monitoring program at the Naturita Disposal Site. The monitoring program includes wells CM93-1, CM93-2, BP95-1, BP95-2, and BP95-3. NRC determined that leakage from the disposal cell is not impacting the uppermost aquifer, and it is unlikely for any future leakage to impact the Salt Wash Member due to lack of significant amount of water in the disposal cell as driving force of infiltration, and stable water levels and water quality have been observed. Therefore, NRC concurred with DOE that continuous monitoring of these wells was no longer needed and approved the termination of the monitoring program (DOE letter dated October 31, 2013; NRC letter dated April 15, 2014). All other wells on Club Mesa were abandoned in 2005 and 2007 with CDPHE approval (CDPHE 2015b).

Umetco's liquid waste handling and disposal operations in the San Miguel River valley released contaminants into the Kayenta-Wingate aquifer. The most significant contribution to groundwater contamination was the disposal of liquid raffinate in the unlined Club Ranch Ponds. Groundwater monitoring well data have identified seepage from the Club Ranch Ponds (E2 2010).

The groundwater system in the San Miguel River valley is a complex, fractured aquifer that maintains a recharge-discharge relationship with the San Miguel River. The groundwater monitoring well system in the river valley detected contamination in the fractured aquifer system. This contaminated groundwater acted as a source of non-point contamination to the San Miguel River. The sandstone matrix likely produces very little liquid relative to the fractures, and may have contributed contaminants to the fracture system at a relatively slow rate (E2 2010).

Sections 5.4.1.2, 5.4.2.2, and 5.4.3.2 of the RAP required the following activities to ensure adequate remediation of the groundwater.

- Collect and dispose of contaminated hillside and toe berm seepage.
- Monitor the Salt Wash wells on Club Mesa.
- Attempt to pump the underground mine workings in Club Mesa Spray area.
- Sample the Club Mesa wells to monitor the Kayenta-Wingate aquifer (CDPHE 2015a).

The RAP also required extraction and evaporation of Kayenta-Wingate groundwater in the Club Ranch Ponds Area. Groundwater pumping was to be conducted at a rate of 60 gallons per minute and operational adjustments were to be made as necessary to maintain optimal system performance. The extracted groundwater was to be conveyed to and evaporated in the lined Club Ranch Ponds. Performance of the groundwater extraction system was to be evaluated annually (E2 2010).

Umetco installed the initial groundwater extraction system in 1991 and upgraded it in 1996 and again in 1998. Groundwater pumping began in 1991 in accordance with the RAP. In 1997, the groundwater cleanup effort was evaluated in detail and an optimized system was developed so that contamination liquids from low-permeability zones in the Kayenta-Wingate aquifer could be extracted. Umetco installed this optimized system in 1998 by drilling and completing 12 new extraction wells. The change in groundwater withdrawal successfully reduced contaminant concentrations (E2 2010).

In general, the groundwater extraction and CRP System has removed approximately 15,000 tons of contaminants from the groundwater flow regime. Throughout the life of the groundwater remedial action, Umetco modified the groundwater monitoring procedures with CDPHE approval to ensure optimum performance of the extraction program and to monitor compliance with groundwater protection standards (E2 2010).

The Kayenta-Wingate aquifer had reached steady state conditions by 2002. The groundwater performance evaluations showed that future groundwater extraction would not significantly enhance aquifer restoration. In 2003, CDPHE approved a groundwater ACL application. ACLs were proposed for 11 groundwater constituents at the Site. The ACLs were developed using a Point of Exposure in the San Miguel River. ACLs were calculated using a mass balance approach for aquifer concentrations that did not exceed the surface water quality standards for the San Miguel River. Action levels well below the ACL values were established so that corrective actions could be identified and implemented prior to degradation of the river. The ACL application implemented a monitoring program that consisted of quarterly monitoring with annual performance evaluations for a period of three years. After three years of monitoring and annual evaluations the program showed that there were no contaminants in the Kayenta-Wingate Aquifer above the ACLs and the ACL monitoring program was terminated. Currently, as required by the ACL application, groundwater is monitored in accordance with the anticipated DOE long-term monitoring for the Site (E2 2010). As indicated in Section 3.3.2, the application of ACLs at the Site will remain unchanged since they were established prior to the 2005 policy guidance document (EPA 2005).

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Section 5
Residual Impacts

Residual impacts to solids and liquids (primarily groundwater) are noted at the Site. Residual impacts within the solids and liquids areas described in Section 4 are summarized in the following Sections.

5.1 Solids

Confirmation investigations were performed to evaluate residual impacts, either from residual mine-related waste or natural sources, in various areas of the Site. The residual contamination is summarized in the following Subsections.

For reference purposes, Appendix C provides the Alternative Soil Standards application approval, Appendix D contains radiation survey and soil sampling maps from confirmation reports referenced in the various Subsections, and Appendix G provides a review of the residual risk associated with the various remedial areas.

5.1.1 Atkinson Creek Disposal Area

Umetco collected reconfirmation soil samples of 18 "hot spots" on August 27, 1991, as documented on Table 4-2 of the March 1994 risk assessment (Umetco 1994a). The results of the reconfirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows.

- Arsenic concentrations in 12 of the 18 samples exceed the Category 1/2 cleanup standard of 21.4 mg/kg, based on the UMC laboratory results. Category 3 (dose/risk-based) standards for arsenic are site-specific and have not been established for Atkinson Creek Crystal Disposal Area. The maximum concentration of arsenic is 40 mg/kg, with an average concentration of 26.4 mg/kg.
- Molybdenum concentrations in all samples tested exceed the Category 1 (RAP-based) standard of 2.3 mg/kg but are below Category 2 (residential risk-based) standard of 370 mg/kg, based on Barringer Laboratory results. Average molybdenum concentrations are 7.0 mg/kg.
- The vanadium concentration for two samples exceeds the Category 1 standard of 60.1 mg/kg but is below the Category 2 standard of 520 mg/kg, based on UMC laboratory results. Average vanadium concentrations are 40.4 mg/kg.
- Thorium-230 results were compared to subsurface (>15 cm) standards, considering the sampled areas have been covered with 1 foot of uncontaminated fill. One soil sample exceeds the Category 1 standard of 17.1 pCi/g but is below the Category 2 standard of 43 pCi/g, based on Barringer Laboratory results. Average thorium concentrations are 5.5 pCi/g.

Umetco performed radiological surveys for exposure rates and surface soil radium-226 in December 2001, as documented in compliance report CR-400-5. An average exposure rate of 13.6 µR/h with a maximum exposure reading of 58.0 µR/h was noted (average exposure in the grid with the maximum reading was 20 µR/h). Radium-226 concentrations averaged 3.4 pCi/g with a maximum single reading of 106.4 pCi/g. The grid with the maximum reading had a reading average of 13 pCi/g. Two grids had reading averages over 7 and less than 17 pCi/g. All Ra-226 grid average results were below the most stringent Category 3 standard (58 pCi/g). CDPHE and Umetco are preparing an alternative soil standards application to send to the NRC for approval of alternative soil standards for these two grids at the Atkinson Creek Disposal Area as described further in Section 6.

5.1.2 Club Ranch Ponds Area

The *Confirmation Investigation Report, Club Ranch Ponds, Uravan, Colorado*, was submitted to CDPHE in June 2007 as Compliance Report CR-401-7I. Confirmation surveys were performed between May 2003 and January 2007. The average exposure rate was measured to be 19.3 µR/hr with a maximum grid measurement of 38 µR/hr. The maximum exposure was measured in a bedrock area. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Radium-226 concentrations derived from scintillometer measurements exceed the Category 1/2 surface soil standard of 7.1 pCi/g in approximately 10 percent of samples, with a maximum reading of 23 pCi/g in a bedrock area. The average concentration is 4.4 pCi/g. CDPHE and Umetco are preparing an alternative soil standards application to send to the NRC for approval of alternative soil standards for 77 grids at Part of Club Ranch Ponds Area that have radium between 7.1 and 58 pCi/g but met the Category 3 standard of the 1999 soil methodology document.

- Radium-226 concentrations in laboratory confirmation soil samples are all below Category 1/2 standards for both surface and subsurface soils.

- The thorium concentration in one sample (43.0 pCi/g in PVSS-22, 15-30 cm) is above the Category 1 subsurface standard of 17.1 pCi/g and equals the Category 2 standard of 43 pCi/g. The areas of two surface samples with concentrations of 19 and 25 pCi/g were subsequently covered with one foot of clean fill; these areas are below Category 2 subsurface soil standards.

- Natural uranium concentrations in five samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum uranium concentration was 11.6 mg/kg detected in a subsurface sample.

- The arsenic concentration in one sample (26.2 mg/kg in PSSV-18, 15-30 cm) exceeds the Category 1/2 cleanup standard of 21.4 mg/kg. Category 3 (dose/risk-based) standards for arsenic are site-specific and have not been established for Club Ranch Ponds.

- Cadmium results in four samples exceeded the Category 1 cleanup standard of 2.0 mg/kg but were below the Category 2 standard of 75 mg/kg (one of the four sample results is an estimated value). The maximum concentration of cadmium was 5.8 mg/kg in a subsurface sample.
- Molybdenum results in four samples exceeded the Category 1 cleanup standard of 2.3 mg/kg but were below the Category 2 standard of 370 mg/kg. The maximum concentration of molybdenum was 16 mg/kg in a subsurface sample.
- Vanadium results in seven samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 118 mg/kg in a surface sample.

5.1.3 River Ponds Area

The Alternative Soil Standards Application (Umetco 2007a) notes that residual contamination from 20 to 60 µR/hr existed as local hot-spots prior to final excavation, and that final verification surveys were not possible due to flooding of the area. These areas were covered by 2 to 3 feet of alluvial sediment and stabilized by riparian vegetation. Alternative standards were proposed for the area for the following reasons:

- Additional excavation would cause environmental harm by damaging the riparian vegetation and the wetland areas that have formed at the remediation site.
- The area met RAP exposure criteria of less than 20 µR/hr.
- No habitable structures would be constructed in the area because the area is within both the floodplain of the San Miguel River and the DOE long-term surveillance area.
- Riprap groins and riparian vegetation form a stabilizing cover over the residual contaminants.
- The cost of remediation would be high compared to the relative decrease in human exposure.
- Previous remediation actions have reduced exposures to ALARA.
- Residential use of the property is assumed to be prohibited.

5.1.4 Tailings Piles

The tailings piles serve as repositories for mine tailings and remediation waste. National Emissions Standards for Hazardous Air Pollutants (NESHAP) monitoring was performed for the tailings piles areas in 2002. The NESHAP and CCR standard (6 CCR 1007-1 Part 18) for Radon-222 emissions is 20 pCi/m^{2}s when averaged over an entire pile or impoundment. The average Radon-222 emissions for the Tailings Pile areas were reported as follows:

- Tailings Piles 1/2: 1.3 pCi/m2s
- Tailings Pile 3: 1.1 pCi/m2s
- B-Plant Repository: 0.7 pCi/m2s

Settlement-monitoring monuments were abandoned in 2007. The tailings piles are monitored for settlement via visual inspection on a quarterly basis, and after the Site receives 0.5 inches or more precipitation. As of the most recent annual report reviewed (2015 annual report), no settlement or slope stability anomalies were reported (Umetco 2016). By letter dated June 15, 2016, CDPHE approved deletion of Procedure E-32 Tailings Stability Monitoring; therefore, settlement monitoring of the B-Plant Repository is no longer required (Umetco 2017).

5.1.5 Club Mesa Area

Confirmation sampling for the Club Mesa Area is summarized in *Confirmation Investigation Report: Club Mesa Spray Area, Uravan, Colorado* (Umetco 1998) submitted as Compliance Report CR-406-5. Remediation generally was completed to bedrock in this area, which contained numerous mineralized zones. The conclusions of the investigation report were as follows:

- One-meter gamma exposure readings ranged from 9 to 430 µR/hr. Areas of higher gamma readings were attributed to mineralized bedrock.
- Based on scintillometer measurements, Radium-226 measurements range from 0 to 863 pCi/g, with an average of 7.1 pCi/g across the site. This value equals the Category 1/2 standard for surface soil. If mineralized zones are subtracted, the average Radium-226 activity is reduced to 6.3 pCi/g.
- Radium-226 concentrations in two mineralized bedrock samples were 95 and 3,070 pCi/g (exceeding Category 2 standards). Concentrations in the unmineralized samples were 1.4 and 3.1 pCi/g (below Category 1 standards).
- Thorium concentrations in two mineralized bedrock samples were 90 and 2,290 pCi/g (exceeding Category 2 standards). Concentrations in the unmineralized samples were 2.0 and 35 pCi/g. The 35 pCi/g concentration exceeds Category 2 standards for surface soil but is below the most stringent Category 3 standard of 58 pCi/G (recreational visitor standard).
- Natural uranium concentrations in two mineralized bedrock samples were 330 and 8,800 pCi/g (exceeding Category 2 standards). Concentrations in the unmineralized samples were 4.5 and 18 pCi/g (below Category 2 standards).
- Radon flux measurements averaged 1.2 pCi/m2/s.
- Risk assessment of radionuclides in unmineralized bedrock indicates potential doses to monitoring workers would be a maximum of 7 mrem/yr at 1,000 years.

5.1.6 Mill Areas

5.1.6.1 A-Plant Area

Confirmation sampling for A-Plant Area is summarized in the *Confirmation Investigation Report: A-Plant, Uravan Colorado* (Umetco 2002a). The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- The average one-meter exposure rate across the Site was reported to be 15.8 µR/hr, with a maximum grid concentration of 56 µR/hr.

- Radium-226 concentrations derived from scintillometer measurements exceed the Category 1/2 surface soil standard of 7.1 pCi/g in approximately 8 percent of the grids surveyed, with a maximum grid concentration of 32 pCi/g. Most of these grids were along the Mill Hillside road.

- Natural uranium concentrations in five samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. Additional soil was subsequently removed from the sample area where the two highest exceedances occurred (A-Plant [AP] 25-A/B); no follow-up sampling for this area is documented. The maximum uranium concentration outside of this additional removal area was 17.2 mg/kg detected in a surface sample.

- Laboratory results for Radium-226 and Thorium-230 are below Category 1 and 2 values, except for the AP-25 A/B samples (additional soil was subsequently removed from this area).

- Molybdenum concentrations in two samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg (maximum concentration 3.4 micrograms per kilogram [µg/kg]). Additional soil was subsequently removed from the sample area where the two exceedances occurred (AP 25-A/B); no follow-up sampling for this area is documented.

- Vanadium results in 10 samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 283 mg/kg in surface sample AP-25B. The maximum concentration outside the AP-25 A/B area (where additional material was subsequently removed) was 127 mg/kg in a surface sample.

The *Appendix to the Confirmation Investigation Report: A-Plant, Uravan, Colorado for A-Plant North.* (Umetco 2007b) documents additional confirmation investigation activities for the A-Plant North area. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- The average 1-meter exposure rate across the Site was reported to be 19.5µR/hr, with a maximum grid concentration of 24 µR/hr.

- Radium-226 concentrations derived from scintillometer measurements exceed the Category 1/2 surface soil standard of 7.1 pCi/g in four of the grid blocks surveyed, each of which had a grid concentration of 8 pCi/g. CDPHE and Umetco are preparing an alternative soil standards application to send to the NRC for approval of alternative soil standards at the A-Plant North Area that has radium between 7.1 and 58 pCi/g but met the Category 3 standard of the 1999 soil methodology document.

- The thorium-230 concentration in one sample (APN-7, 17 pCi/g) exceeded the Category 2 cleanup objective of 14 pCi/g. This area was subsequently covered with 1 foot of clean fill, meaning that subsurface standards now apply to the residual contamination. The concentration is below Category 1 and 2 subsurface standards for Thorium-230. All other Thorium-230 concentrations were below applicable Category 1and 2 standards.

- Natural uranium concentrations in seven samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 24.1 mg/kg in a subsurface sample.
- Vanadium results in five samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 97.3 mg/kg in a surface sample.

5.1.6.2 B-Plant Area

Confirmation sampling for B-Plant Area is summarized in the *Confirmation Investigation Report: B-Plant, Uravan Colorado* (Umetco 2002b). The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- The average 1-meter exposure rate across the Site was reported to be 28.8 µR/hr, with a maximum exposure rate of 357 µR/hr. The majority of high-exposure grids were in areas of exposed bedrock.
- Radium-226 concentrations derived from scintillometer measurements averaged 13.4 pCi/g across the site. The maximum averaged exposure for a 10-by-10-meter grid was 490 pCi/g.
- Radium-226 concentrations in laboratory confirmation soil samples exceed Category 1/2 values in three surface samples and one subsurface sample. The maximum concentration of Radium-226 was measured to be 28.3 pCi/g in the subsurface sample.
- Thorium-230 concentrations exceed Category 1 surface standards in four samples and Category 2 surface standards in two of those samples. One subsurface sample exceeds Category 1 subsurface standards. The maximum concentration of Thorium-230 was 33.7 pCi/g in a surface sample.
- Natural uranium concentrations in six samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 43 mg/kg in a subsurface sample. Uranium concentrations were J-flagged (estimated quantity) for all samples.
- Arsenic concentrations in two samples (BP-10A, 35 mg/kg and BP-10B, 121 mg/kg) exceed the Category 1/2 standard of 21.4 mg/kg.
- Molybdenum concentrations in two samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 20.8 mg/kg in a subsurface sample.
- Vanadium results in four samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 272 mg/kg in a surface sample.

5.1.7 Town and Adjacent Areas

Details regarding residual contamination in the town and adjacent areas are included in the subsections below.

5.1.7.1 Town Area

Confirmation sampling for the Town Area is summarized in the *Confirmation Investigation Report: Town Area, Uravan Colorado* (Umetco 2003a), submitted as Compliance Report CR-418G-3. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- The average 1-meter exposure rate across the site was reported to be 16.9 µR/hr, with a maximum average grid exposure rate of 39 µR/hr. Most grids with exposure rates exceeding 20 µR/hr are located along steep sections abutting Highway 141, along the San Miguel River, or along a bedrock cliff near the center of town.
- Radium-226 concentrations derived from scintillometer measurements averaged 4.3 pCi/g across the site. The maximum averaged exposure for a 10-by-10-meter grid was 64 pCi/g. Two grids with less than six total readings available for averaging had readings of 65 and 74 pCi/g. Grids with radium-226 concentrations exceeding 7.1 pCi/g generally are in the same areas with exposure rate exceedances. CDPHE and Umetco are preparing an alternative soil standards application to send to the NRC for approval of alternative soil standards for 89 grids at the Town Area that have radium between 7.1 and 58 pCi/g but met the Category 3 standard of the 1999 soil methodology document.
- Radium-226 concentrations in laboratory confirmation soil samples exceed Category 1/2 values in one surface sample (17 pCi/g in sample UT 14-1).
- Thorium-230 concentrations exceed Category 1 surface standards in five samples and Category 2 surface standards in one of those samples. One subsurface sample exceeds Category 1 subsurface standards but is below Category 2 standards. The maximum concentration of Thorium-230 was 23 pCi/g in the subsurface sample.
- Natural uranium concentrations in 13 samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 52 mg/kg (estimated) in a surface sample.
- Arsenic concentrations in two samples (UT-15-9-00A, 27 mg/kg and UT-15-9-00B, 67 mg/kg) exceed the Category 1/2 standard of 21.4 mg/kg.
- Cadmium concentrations in two samples (UT-15-9-00A, 2.5 mg/kg and UT-15-9-00B, 5.9 mg/kg) exceed the Category 1 standard of 2.0 mg/kg but are below the Category 2 standard of 75 mg/kg.
- Lead concentrations in one sample (UT-15-9-00B, 610 mg/kg) exceed the Category 2 cleanup standard of 400 mg/kg. Category 3 standards for lead are 1,500 mg/kg for monitoring workers and ranchers, and require calculation (using the IEUBK Model method) for recreational visitors.

- Molybdenum concentrations in four samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 14 mg/kg in a subsurface sample.
- Vanadium results in 11 samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 118 mg/kg in a surface sample.
- Zinc concentrations in three samples exceeded the Category 1 cleanup standard of 422 mg/kg but were below the Category 2 standard of 22,000 mg/kg. The maximum concentration of vanadium was 1,200 mg/kg in a subsurface sample.

5.1.7.2 Town Dump

Confirmation sampling for the Town Dump is summarized in the *Confirmation Investigation Report: The Town Dump, Uravan Colorado* (Umetco 1999b), submitted as Compliance Report CR-419-3. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- The arithmetic-mean one-meter exposure rate across the Site was calculated to be 13.8 µR/hr, with a maximum grid average of 23 µR/hr. Seven 10-by-10-meter grids had average exposures greater than 20 µR/hr, five in an exposed bedrock area and two along an unpaved road.
- Radium-226 concentrations derived from scintillometer measurements averaged 4.3 pCi/g across the site. The maximum uncorrected averaged exposure for a 10-by-10-meter grid was 12pCi/g. Five grids had average uncorrected values exceeding the Category 1/2 surface standard of 7.1 pCi/g. A correction of -1.9 pCi/g per grid was applied to the data for contributions from thorium-232 decay-chain radionuclides and potassium-40, based on the DOE Surface Gamma-Ray Measurement Protocol (DOE 1984). Based on the corrected values, three of the five grids remained over 7.1 pCi/g. The corrected values for these three grids were then calculated for a weighted average using a method set forth in the NRC document Manual for Conducting Radiological Surveys in Support of License Termination (NRC 1992). Using this method, two grids remained above 7.1 pCi/g. These two grid areas were covered with a minimum of 15 centimeters of clean fill during final site grading so that the areas met the subsurface standard of 17.1 pCi/g.
- Radium-226 concentrations in laboratory confirmation soil samples were below Category 1/2 values in all samples.
- Thorium-230 concentrations exceed Category 1 surface standards in two samples and Category 2 surface standards in one of those samples. The sample area that exceeded Category 2 standards (TDP-06AR) was covered with a minimum of 15 centimeters of clean fill during final site grading so that the area met the subsurface Category 1/2 standards. One subsurface sample exceeds Category 1 subsurface standards but is below Category 2 standards. The maximum concentration of Thorium-230 was 25.5 pCi/g in the subsurface sample.

- Natural uranium concentrations in eight samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 32 mg/kg in a surface sample.
- Molybdenum concentrations in three samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 22 mg/kg in a subsurface sample.
- Vanadium results in two samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 97 mg/kg in a surface sample.

5.1.7.3 Windblown Area

The report *Characterization of Areas of Elevated Radioactivity Levels: The Windblown Area* (Umetco 2003b) details the results of exposure surveys conducted in 1998 and 2000. Section 4.7.2.4 of the RAP requires removal of concentrated deposits with exposure readings greater than 30 µR/hr, but does not require removal of general windblown material. Grid blocks with exposure readings exceeding 30 µR/hr were classified into 12 areas (Area A through Area L). Elevated exposure readings in all areas except Area E and Area J were attributed to NORM outcrops or uranium waste-rock piles.

Elevated exposure readings in Area E were attributed to general, non-discrete windblown deposits. Umetco collected 12 soil samples in Area E during 2005 to evaluate radionuclides and heavy metals. The results of this sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Radium-226 concentrations in six samples exceed the Category 2 surface standard of 7.1 pCi/g, with a maximum concentration of 16 pCi/g.
- Thorium-230 concentrations in six samples meet or exceed the Category 2 surface standard of 14 pCi/g, with a maximum concentration of 36 pCi/g.
- Natural uranium concentrations in all samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 48.7 mg/kg.
- Vanadium results in 10 samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 176 mg/kg.

An additional radiological survey of the North 40 area was performed in 2002 and 2003 and submitted as Compliance Report CR-418B-3. Numerous grids had exceedances of the Category 1/2 surface standard of 7.1 pCi/g for Radium-226. The areas of elevated readings were attributed in the compliance report to naturally occurring outcrops of uranium ore in the Salt Wash Sandstone.

5.1.7.4 Mill Hillside

Alternate Soils Standards were requested for the Mill Hillside area in the Alternative Soils Standards Application (Umetco 2007a). An average exposure rate of 35.1 µR/hr was measured for the area with a maximum exposure of 202 µR/hr for a single 10-by-10-meter grid. Average Ra-226 concentrations were measured to be 22 pCi/g with a maximum exposure of 173 pCi/g for a single 10-by-10-meter grid. Confirmation soil sampling measured average Ra-226 concentrations to be 17.1 pCi/g for surface samples and 10.5 pCi/g for subsurface (15-30 cm) samples, with a maximum concentration of 103.5 pCi/g in a surface sample. NORM were noted on the mill hillside. Based on a risk assessment performed for the area, maximum human exposure would occur for a hunter-hiker using the area and ingesting meat from an animal harvested in the area. The annual radiation dose to such a hiker would be 4.6 mrem, below a 25 mrem per year public radiation dose standard. Alternative standards were proposed for the following reasons:

- The steep hillsides pose a risk of injury to construction workers during potential additional remediation.
- Remedial actions could result in destabilization of the slope and release of sediment to drainages (and ultimately the San Miguel river), causing excessive harm to the environment.
- No habitable structures will be constructed in the area because of future ICs and stewardship of the land by the DOE.
- Cost of remediation would be excessive in relation to small decrease in human exposure.
- Previous remediation actions reduced exposures to ALARA.
- Future land use will be habitat for wildlife and not for residential or related structures. The DOE will assume long-term stewardship of the property and manage land use.

The *Confirmation Investigation Report: Mill Hillside, Uravan, Colorado* (Umetco 2002c) was submitted as Compliance Report CR-418C-3. The soil sampling results are summarized as follows:

- Natural uranium concentrations in the majority of samples exceeded the Category 1 standard of 8.4 mg/kg and exceed the Category 2 standard of 220 mg/kg in two samples with a maximum of 611 mg/kg found in the surface sample. Uranium concentrations are below the most stringent Category 3 standard of 3,800 mg/kg (rancher standard).
- Molybdenum concentrations in seven samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 7 mg/kg in a surface sample.
- Vanadium results in the majority of samples exceeded the Category 1 cleanup standard of 60.1 mg/kg and exceed the Category 2 standard of 520 mg/kg in three samples. The maximum concentration of vanadium was 1,020 mg/kg in a surface sample. This value is below the most stringent Category 3 standard of 1,300 mg/kg (recreational visitor standard).

5.1.7.5 County Road Y-11

Radiological surveys of the roadway were performed in February and April 2007, and reported in CR-418D-2. The results indicated the removal of the discrete visible tailings had reduced the average radium-226 concentration to 4.5 pCi/g, below the RAP guideline of 7.1 pCi/g. However, some areas with radium-226 concentrations over 7.1 pCi/g remained and are located approximately 1,000 feet west of the intersection of County Road Y-11 with County Road V-18. The County Road Y-11 roadway and right-of-way were included in the Alternative Soil Standards Applications for the following reasons:

- Potential health risks are negligible as contaminated material are only present at depths greater than 3 feet, and future exposures will be minimized by ICs.
- Cost of remediation would be excessive in relation to small decrease in human exposure.
- Previous remediation actions reduced exposures to ALARA.
- Future land use will be as a road and not for residential or related structures. The DOE will assume long-term stewardship of the property and manage land use.

5.1.7.6 County Road EE-22

Confirmation Investigation Report, Montrose County Road EE-22, Uravan, Colorado was submitted in December 2002 as Compliance Report CR-418E-3. The laboratory confirmation soil sample results cited here and presented in the CR-418E-3 were from the soil samples taken during the characterization investigation in 1998 prior to remedial, backfilling, and regrading activities in 2000 and 2001. No post-reclamation soil samples were taken because the road was backfilled after remediation to maintain the road traffic. Therefore, these soil sample results are not representative of post-reclamation or current conditions. The average pre-excavation exposure rate was below the 30 µR/hr standard specified in Section 4.7.2.4.1 of the RAP, although some individual grid averages exceed 30 µR/hr with a maximum average grid concentration of 96 µR/hr. Sampling results compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Based on scintillometer surveys, radium-226 averaged concentrations in some grid blocks exceed the Category 1/2 surface standard of 7.1 pCi/g, with a maximum concentration of 25 pCi/g. These concentrations are below the most stringent Category 3 dose/risk-based standard of 58 pCi/g (recreational visitor standard). CDPHE and Umetco are preparing an alternative soil standards application to send to the NRC for approval of alternative soil standards for 73 grids at the County Road EE-22 Area that have radium between 7.1 and 58 pCi/g but met the Category 3 standard of the 1999 soil methodology document.
- Radium-226 concentrations in the majority of laboratory confirmation soil samples exceed Category 1/2 values. Concentrations in two of the samples exceed the least stringent Category 3 dose/risk based standard of 170 pCi/g (rancher standard). The maximum concentration was 219 pCi/g in a surface sample.

- Thorium-230 concentrations in the majority of laboratory confirmation soil samples exceed Category 1/2 values. Concentrations in two of the samples exceed the least stringent Category 3 dose/risk based standard of 170 pCi/g (rancher standard). The maximum concentration was 272 pCi/g in a surface sample.
- Natural uranium concentrations in the majority of samples exceeded the Category 1 standard of 8.4 mg/kg and exceed the Category 2 standard of 220 mg/kg in five samples. The maximum concentration of natural uranium detected is 620 mg/kg in a surface sample.
- Arsenic concentrations in four samples exceed the Category 1/2 standard of 21.4 mg/kg. The maximum concentration of arsenic detected was 31 mg/kg in a surface sample.
- Cadmium results in three samples exceeded the Category 1 cleanup standard of 2.0 mg/kg but were below the Category 2 standard of 75 mg/kg. The maximum concentration of cadmium was 5.7 mg/kg in a subsurface sample.
- Lead concentrations in one sample (EE22-23B, 520 mg/kg) exceed the Category 2 cleanup standard of 400 mg/kg. Category 3 standards for lead are 1,500 mg/kg for monitoring workers and ranchers, and requires calculation (using the IEUBK Model method) for recreational visitors.
- Molybdenum concentrations in six samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 6.6 mg/kg in a surface sample.
- Vanadium results in the majority of samples exceeded the Category 1 cleanup standard of 60.1 mg/kg and exceed the Category 2 standard of 520 mg/kg in six samples. Three values exceed the most stringent Category 3 standard of 1,300 mg/kg (recreational visitor standard) but are below the second-most stringent Category 3 standard of 7,100 mg/kg (monitoring worker). The maximum concentration of vanadium was 1,740 mg/kg in a subsurface sample.

5.1.7.7 Water Storage Ponds

Confirmation sampling for the Water Storage Ponds Area is summarized in the *Confirmation Investigation Report: Water Storage Ponds, Uravan Colorado* (Umetco 2000), submitted as Compliance Report CR-418F-3. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Based on scintillometer surveys, average exposure across the area was 16 µR/hr with a maximum grid average of 30 µR/hr. Thirteen grids had average exposure readings greater than 20 µR/hr.
- Based on scintillometer surveys, radium-226 averaged concentrations in three grid blocks equal the Category 1/2 surface standard of 7.1 pCi/g. These concentrations are below the most stringent Category 3 dose/risk-based standard of 58 pCi/g (recreational visitor standard).

- The Radium-226 concentration in one laboratory confirmation soil sample (13.9 pCi/g in WSP-04RA) exceeds the Category 1/2 value of 7.1 pCi/g for surface soil. A minimum of 15 centimeters of fill was placed over this area during final grading, and as a result the value meets the Category 1/2 subsurface standard of 17.1 pCi/g.
- The Thorium-230 concentration in one laboratory confirmation soil sample (17.1 pCi/g in WSP-04RA) exceeds the Category 2 value of 14pCi/g for surface soil. This concentration is below the most stringent Category 3 dose/risk-based standard of 58 pCi/g (recreational visitor standard). A minimum of 15 centimeters of fill was placed over this area during final grading, and the value is below the Category 2 subsurface standard of 43 pCi/g.
- Natural uranium concentrations in six samples exceeded the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 31 mg/kg in a surface sample.
- Molybdenum concentrations in two samples exceed the Category 1 standard of 2.3 mg/kg but are below the Category 2 standard of 370 mg/kg. The maximum concentration detected was 3.6 mg/kg in a subsurface sample.
- Vanadium results in five samples exceeded the Category 1 cleanup standard of 60.1 mg/kg but were below the Category 2 standard of 520 mg/kg. The maximum concentration of vanadium was 147 mg/kg in a surface sample.

5.1.7.8 Atkinson Creek Drainage Way

A characterization scintillometer survey was conducted in May 1990. No readings greater than 20 µR/hr were observed along the streambed and therefore no remedial activities were required. A confirmation scintillometer and soil sampling survey were conducted on December 17, 1992, which also indicated no readings over 20 µR/hr. Radionuclide and metal concentrations in the soil samples are below Category 1 cleanup levels. The results of both surveys were submitted to CDPHE on December 28, 1992, and were also detailed in the Characterization Investigation Report and Remedial Action Plan for Atkinson Creek Streambed, Uravan, Colorado, dated May 5, 1994. These activities were documented in Compliance Report CR-418H-1, approved by CDPHE on February 19, 2002 (CDPHE 2015a).

5.1.7.9 Hieroglyphic Canyon Drainage Way

Pre-remediation activities identified hot-spot soils with exposure readings exceeding 30 µR/hr. A no-action alternative was proposed for the Hieroglyphic Canyon Drainage Way, with the exception that discrete deposits of contaminated materials would be remediated where accessible. In the approval letter dated April 6, 1995, CDPHE agreed to limit the remediation activities to the removal of accessible mill-related contamination within the stream channel and the radioactive hot spots on the canyon slopes. In this letter, CDPHE also requested a Materials Identification and Removal Plan. The plan was submitted on August 17, 1995, and stated that contaminated material would be removed from the canyon mouth to an area upstream where movement of materials and equipment would be restricted. In addition, to ensure that stream sediments continue to meet appropriate standards, contaminated soils also would be removed from the area known as Treasure Island and from the rim of Club Mesa (CDPHE 2015a).

Cleanup activities took place in 1991 and 1994 at the replacement location of the County Bridge and along the rim of the canyon, respectively. Additional cleanup work was performed between June 1998 and February 1999 with the removal of contaminated soils from the mouth of Hieroglyphic Canyon and the Treasure Island area. Iterative cleanup was conducted in August and September 2000. These activities are documented in Compliance Report CR-418I-1 (CDPHE 2015a). In accordance with the Materials Identification and Removal Plan, no confirmatory sampling or surveying was performed.

5.1.7.10 Northeast Side of Colorado Highway 141

Compliance Report CR-418J-3 includes the *Confirmation Investigation Report: Northeast of Highway 141, Uravan, Colorado* (Umetco 2002d). The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Based on scintillometer surveys, average exposure across the area was 16.9 µR/hr with a maximum average for one grid of 35 µR/hr. If just the area outside the highway right-of-way is considered, the average exposure is 16.1 µR/hr with a maximum grid average of 23 µR/hr.
- Based on scintillometer surveys, radium-226 averaged concentrations in numerous grid blocks exceed the Category 1/2 surface standard of 7.1 pCi/g, with a maximum concentration of 39 pCi/g. If the area just outside the highway right-of-way is considered, 22 grid blocks exceed the Category 1/2 surface standard of 7.1 pCi/g, with a maximum concentration of 28 pCi/g. These concentrations are below the most stringent Category 3 dose/risk-based standard of 58 pCi/g (recreational visitor standard).
- The Radium-226 concentration in four laboratory confirmation soil samples exceed the Category 1/2 value of 7.1 pCi/g for surface soil, with a maximum concentration of 11 pCi/g. Two of the four samples were outside the highway right-of-way.
- Thorium-230 concentrations in nine surface samples exceed the Category 1 surface soil standard of 7.1 pCi/g but are at or below the Category 2 standard of 14 pCi/g. The thorium concentration in one subsurface sample exceeds the Category 1 standard of 17.1 pCi/g but is below the Category 2 standard of 43 pCi/g.
- Natural uranium concentrations in 13 samples exceed the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 23 mg/kg in a surface sample.
- The vanadium result in one sample (70 mg/kg in 141-12B) exceeds the Category 1 cleanup standard of 60.1 mg/kg but is below the Category 2 standard of 520 mg/kg.

CDOT performed additional removal beneath the Highway 141 right-of-way during realignment of a section of the highway in winter and spring of 2006. The removals took place between mileposts 75 and 76 of the highway. Confirmation sampling from the removal activity is documented in the report *Final Construction and Soil Confirmation Investigation Report: Colorado Department of Transportation Highway 141, Uravan Colorado* (Umetco 2006b). This portion of the site was deleted from the Superfund Site on September 4, 2007. The results of confirmation

sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Based on scintillometer surveys, average exposure across the area was 17.9 µR/hr, with a maximum average for one grid of 33 µR/hr.
- Based on scintillometer surveys, radium-226 averaged concentrations in 22 grid blocks exceed the Category 1/2 surface standard of 7.1 pCi/g, with a maximum concentration of 16 pCi/g. Average radium-226 readings across the site were 4.1 pCi/g. The 16 pCi/g reading was contributed to the historic use of coal fly ash for icy road maintenance (based on field observations.
- The thorium concentration in one subsurface sample (23 pCi/g) exceeds the Category 1 standard of 17.1 pCi/g but is below the Category 2 standard of 43 pCi/g.
- Natural uranium concentrations in 3 samples exceed the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. The maximum concentration detected was 52 mg/kg in a surface sample.
- The molybdenum concentration in one sample (4 mg/kg) exceeds the Category 1 standard of 2.3 mg/kg but is below the Category 2 standard of 370 mg/kg.
- Vanadium results in two samples the Category 1 cleanup standard of 60.1 mg/kg but is below the Category 2 standard of 520 mg/kg. The maximum vanadium concentration was 114 mg/kg.

5.1.7.11 The Nature Conservancy Visitor's Site

The *Confirmation Investigation Report: Nature Conservancy Visitor's Site, Uravan, Colorado* (Umetco 1999c) was submitted for CDPHE review in December 1999. The results of confirmation sampling compared to the 1999 Site-Specific Soil Cleanup Objectives document (Umetco 1999a) are summarized as follows:

- Based on scintillometer surveys, average exposure across the area was 14.2 µR/hr, with a maximum average of 15.4 µR/hr.
- Based on scintillometer surveys, radium-226 averaged concentrations in 3 grid blocks exceed the Category 1/2 surface standard of 7.1 pCi/g, with a maximum concentration of 9 pCi/g. The concentration for the 9 pCi/g block corrected for Th-232 and K-40 (DOE surface gamma-ray measurement protocol) is 6.9 pCi/g, below the standard. Average radium-226 readings across the site were 2.9 pCi/g.
- The Thorium-230 concentration in four surface samples exceed the Category 1 surface soil standard of 7.1 pCi/g and one of the samples exceed the Category 2 standard of 14 pCi/g.
- Natural uranium concentrations in three samples exceed the Category 1 standard of 8.4 mg/kg but are below the Category 2 standard of 220 mg/kg. One of the uranium concentrations is J-flagged (estimated concentration).

5.1.8 Burbank Quarry

The Burbank Quarry serves as a repository for raffinate crystals and associated waste. NESHAP monitoring was performed for the lower Burbank Quarry repository in 1998. The NESHAP and CCR standard (6 CCR 1007-1 Part 18) for Radon-222 emissions is 20 pCi/m^{2}s when averaged over an entire pile or impoundment. The average Radon-222 emissions for the repository was 0.9 pCi/m^{2}s.

Settlement-monitoring monuments were abandoned in 2007. The repository is monitored for settlement via visual inspection on a quarterly basis, and after the Site receives 0.5 inches or more precipitation. As of the most recent settlement monitoring (2015 annual report), no settlement or slope stability anomalies were reported (Umetco 2016).

5.1.9 Borrow Areas on Club Mesa

The Borrow Areas on Club Mesa were not contaminated and were used as sources of the clayey soils and random backfill to be used during remedial activities. Therefore, no confirmation surveys were needed or performed. Residual contamination with respect to mining or milling operations is not expected to be present in this area.

5.2 Liquids

Seeps and ponded liquids at the Site appear to be generally mitigated. Groundwater and surface water (San Miguel River) monitoring continues on an annual basis. Specific residual impacts to liquids are summarized in the subsections below.

5.2.1 Hillside Seepage and Tailings Liquids

The hillside seepage collection system was dismantled in 2003. There are no known current issues with residual seepage or contamination. Monitoring of the San Miguel River continues on an annual basis to monitor overall Site impacts to the river (Umetco 2017).

5.2.2 Ponded Liquids and Surface Runoff

No known discharges are occurring that require a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits for the Site were terminated in 1985. Annual monitoring of the San Miguel River continues on an annual basis to monitor overall Site impacts to the river (Umetco 2017).

5.2.3 Surface Water

Monitoring data from samples collected at three monitoring stations along the San Miguel River during the third quarter of 2015 were used to assess potential environmental impacts to the river. The sample data from Station 1 (at the Ball Park), Station 4 (at the Club Ranch Trestle), and Station 5 (at the mouth of Atkinson Creek) is presented in the 2016 Annual Uravan Report as Appendix E to this report (Umetco 2017).

TDS, aluminum, cadmium, iron, manganese, selenium, uranium, sulfate, and un-ionized ammonia concentrations have been evaluated using the trend plot analyses shown in Graphs D-1-1 through D-1-15 (see Appendix E). As requested by CDPHE during the 2015 Annual Inspection, trend plot analyses of all the sampled analytes were provided in the report. In addition, CDPHE requested that the analytical data not be adjusted by removing background concentrations, as have

previously been reported. In the past, background concentrations, observed at Station 1, were subtracted from the downstream concentrations (Stations 4 and 5) and the resultant concentration compared to the river standard to assess any potential impacts to the river from the Site. The trend analyses indicate that analyte concentrations at each sampling station are similar and that there are no impacts to the river from the Site.

The trend plot for TDS (Graph D-1-1 – see Appendix E) shows an overall decrease in TDS concentrations at Station 5 (downstream) over the last five years. This decrease is consistent with the lower concentrations observed at Station 1 (upstream). The trend plot for un-ionized ammonia (Graph D-1-12 – see Appendix E) shows that there is some continuing contribution from the groundwater plume beneath the former Club Ranch Ponds as increases in concentrations occur between Station 4 and Station 5, but that the concentration continues to decrease and remains well below the water quality standard for the San Miguel River of 0.06 milligrams per liter (mg/L). The plots for TDS, calcium, and magnesium show that the water chemistry remains very similar from upstream to downstream of the Site.

Prior to and during the initial stages of site remedial activities in the 1980s, water quality standards were exceeded for elements such as aluminum and un-ionized ammonia. Remedial activities have reduced contaminant flux to the river to levels that have no significant impact on the river system since the evaluated analytes at Station 5 are below applicable standards.

The post-operational surface water monitoring set forth in the CDPHE-approved Application for Alternate Concentration Limits, Uravan Project Site, dated July 2003, was completed in 2006. However, monitoring will continue in anticipation of the DOE continuance of surface water monitoring under the Long-Term Surveillance Program.

5.2.4 Groundwater

Groundwater monitoring currently consists of annual sampling of three wells at the Site (CRP-19A, CRP-25, and background well CRP-1). The most recent available data for these wells (September 2016) are presented in Exhibit 5-1.

Exhibit 5-1 2016 Groundwater Monitoring Results

Constituent	Unit	ACL	CRP-1	CRP-19A	CRP-25	Mean Concentration
Aluminum	mg/L	7.9	<0.03	<0.06	<0.3	<0.18
Ammonium	mg/L	6,900	<0.05	36	640	338
Cadmium	mg/L	0.26	<0.0001	0.0249	0.01	0.02
Iron	mg/L	130	<0.02	<0.04	<0.2	0.12
Manganese	mg/L	130	<0.005	3.59	5.74	4.66
Natural Uranium	mg/L	5.5	0.0002	0.086	0.156	0.12
Nickel	mg/L	21	<0.008	<0.02	0.19	0.10
Nitrate + Nitrite (as N)	mg/L	1,360	0.16	20.3	22.5	21.4
Selenium	mg/L	0.5	0.0007	0.0066	0.209	0.11
Sulfate	mg/L	32,600	36.5	1,860	9,380	5,620
Thorium-230	pCi/L	8,200	0.01	0.02	-0.02	0

Notes:

ACL = Alternate Concentration Limit, mg/L = milligrams per liter, pCi/L = picocuries per liter

The mean concentration of ACL constituents is currently compared to the individual ACLs. If an ACL exceedance is noted, Uravan Groundwater Monitoring Procedure E-11 requires corrective action including additional sampling of wells CRP-19B, CRP-19C, and CRP-21. Groundwater monitoring conducted in the Club Ranch Ponds area continues to demonstrate that ACLs for constituents of concern were met during post-operational monitoring established in the ACL application.

Section 6
Findings and Recommendations

This section provides a summary of the remedial action and residual contamination present at the Site. In addition, this section provides recommendations to address long-term protectiveness.

6.1 Summary of Remedial Action and Residual Contamination

Under the CD, Umetco was required to complete the following general remedial activities as specified in the RAP, as amended.

- Determine the extent of dispersed contamination and clean up areas found to be contaminated to applicable criteria for approximately 400 acres.
- Relocate more than 3 million cubic yards of mill wastes and contaminated materials to secure repositories on Club Mesa.
- Construct waste and tailing repository covers, liquid evaporation and retention ponds, and permanent runoff control structures, utilizing more than 1.7 million cubic yards of earthen materials.
- Construct five double-lined ponds (totaling 40 acres) for the evaporation of hillside seepage, tailing pile seepage, and extracted groundwater.
- Construct and utilize a new repository in the "B-Plant" area capable of disposing in excess of 1.8 million cubic yards of evaporative pond demolition debris and radioactive waste.
- Demolish and remove about 50 major mill facility structures and buildings, including the process systems and circuits, and remove over 260 buildings in the former Town of Uravan.
- Collect over 70 million gallons of hillside and tailing seepage, containing approximately 6,000 tons of contaminated inorganic compounds. Hillside and tailing seepage that was collected was transferred to Club Ranch Ponds for management by evaporation.
- Extract approximately 245 million gallons of contaminated liquids from the groundwater with the removal of approximately 14,500 tons of contaminated inorganic compounds. Contaminated groundwater that was collected was transferred to Club Ranch Ponds for management by evaporation.
- Remove contaminated materials from the Old and New Town Dumps with placement into the Club Mesa Tailing repository.

A summary of remedial activities is provided in the sections below for the nine solids areas (including town subareas) and five liquids remedial activities described in the RAP.

6.1.1 Solids

Management of solids generally consisted of excavation of contaminated material, placement of material in onsite repositories, and Site restoration. A summary of remedial activities for each area identified in the RAP is provided below.

- Atkinson Creek Crystal Disposal Area. Approximately 113,000 cubic yards of contaminated soil and raffinate crystals were removed. The site was graded with 1 foot of clean fill and revegetated.
- Club Ranch Ponds Area. Reclamation of the ponds occurred in three phases. Phases 1 and 2 included construction of new lined evaporation ponds for transfer of material from unlined ponds and for collection/evaporation of collected groundwater. Phase 3 consisted of removal of the ponds, disposal of contaminated media, and site restoration.
- River Ponds Area. Approximately 332,500 cubic yards of contaminated material was excavated from the floodplain to below historic flow elevation. Restoration consisted of placing riprap to enhance siltation.
- Tailings Piles. Remediation activities for Tailings Piles 1 and 2, Tailings Pile 3, and the B-Plant Repository that included dewatering, construction of drainage features, and capping.
- Club Mesa Area. Over 550,000 cubic yards of raffinate crystals, contaminated soil, and neutralized sludge were removed and placed in onsite repositories.
- Mill Areas. Remediation of the A-Plant and B-Plant areas was conducted in stages and included decommissioning of mill structures, removal of contaminated materials, and site restoration.
- Town Area. Over 236,000 cubic yards of contaminated materials were removed from the Town Area and placed in onsite repositories. The Town Area was then reclaimed and revegetated.
- Town Dump. Over 264,000 cubic yards of contaminated materials were removed from the town dump and placed in the B-Plant repository. The area was then reclaimed and revegetated.
- Windblown Area. Exposure in most windblown areas was attributed to NORM. Residual impacts were noted for Area E and Area J. Tailings slimes were removed from Area J.
- Mill Hillside. Approximately 23,000 cubic yards of contaminated materials were removed from the mill hillside and placed in onsite repositories. Terraces were established to reduce erosion and enhance the hillside seepage collection system.
- County Road Y-11. Approximately 8,600 cubic yards of contaminated materials were removed from select portions of the roadway in 2006. Risk assessment was performed for deeper contamination along the roadway.

- County Road EE-22. Approximately 6,230 cubic yards of contaminated material was removed from the right-of-way, and the roadway was restored. Paving of the roadway was recommended.
- Water Storage Ponds. Approximately 17,500 cubic yards of contaminated soil were removed and placed in onsite repositories. The area was then reclaimed and revegetated.
- Atkinson Creek Drainage Way. Radionuclide and metal concentrations in soil samples were found to be below background levels. No remediation was performed.
- Hieroglyphic Canyon Drainage Way. Discrete deposits of contaminated material were removed from the drainage way and placed in onsite repositories. No further action was proposed.
- Northeast Side of County Highway 141. Removals were conducted to the northeast of the right-of-way in 2000 and within the right-of-way during 2006.
- Nature Conservancy Visitor's Site. Approximately 4,800 cubic yards of contaminated soil were removed and placed in the B-Plant repository. The site was reclaimed and revegetated. This cleanup was not proposed in the RAP.
- Other Town Areas. Based on contaminant levels reported to be below background levels, no remedial action was performed at the Corrals, E Block, F Block, Gym Area, Ball Park, or Homer Woods.
- Burbank Quarry. The lower portion of the quarry was used as a repository for onsite materials. The upper portion of the quarry was used as a Title 1 Repository by the DOE for disposal of waste from the nearby Naturita processing site. The repository areas were capped, and drainage materials were installed.
- Borrow Areas on Club Mesa. The borrow areas were not contaminated and were used as backfill sources during remediation activities.
- Two partial deletions from the NPL have been documented for this Site.
    - On February 18, 2005, 9.84 acres of the Site which formerly contained 2 historic structures, the Boarding House and the Community Center, was deleted from the NPL.
    - Additionally, on September 4, 2007, a second partial deletion occurred of approximately 7 acres comprising a one mile section of Highway 141 between mile posts 75 and 76.

Residual impacts were primarily assessed through confirmation surveys at the various areas and subareas. Exhibit 6-1 and Exhibit 6-2 shows a summary of contaminant exceedances in these areas.

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Exhibit 6-1 Summary of Soil Cleanup Objectives, Average Residual Contaminant Values, and Exceedances in Soil

Description	One-Meter Gamma Exposure Rate, Average µR/hr	Surface Soil Radium-226 Concentration, Average pCi/g	Radium-226 pCi/g	Thorium-230 pCi/g	Natural Uranium mg/kg	Arsenic mg/kg	Cadmium mg/kg	Lead mg/kg	Molybdenum mg/kg	Nickel mg/kg	Selenium mg/kg	Vanadium mg/kg	Zinc mg/kg
Soil Cleanup Objectives													
Category 1 Maximum Concentration	20	7.1	7.1 [2] 17.1 [3]	7.1 [2] 17.1 [3]	8.4	21.4	2	164	2.3	25.1	11.2	60.1	422
Category 2 Maximum Concentration	N/A N/A	N/A N/A	7.1 [2] 17.1 [3]	14 [2] 43 [3]	220	21.4	75	400	370	1400	370	520	22000
Check of Category 2 Screening Levels Metals - EPA Regional Screening Levels (May 2016) for Residential Soil [11], Radionuclides - EPA residential PRGs based on 1E-06 cancer risk [12].	N/A	N/A	0.012	0.054	230	0.68 [13]	71	400	390	1500	390	390 (Vanadium and compounds), 460 (vanadium pentoxide)	23000
Category 3 Recreational Visitor Maximum Concentration	N/A N/A	N/A N/A	58	58	5.60E+03	*site specific*	1.90E+03	--- [4]	9.40E+03	3.40E+04	9.40E+03	1.30E+04	5.60E+05
Average Residual Concentration by Remediation Area[10]													
Atkinson Creek Crystal Disposal Area [5], surface	13.6	3.4	1.4	3.8	3.2	3.5	0.5	6.8	2.9	4.2	0.2	15.5	21.3
Club Ranch Ponds, surface	19.3	4.4	2.94	9.83	6.45	7.79	1.1	41.85	2	6.88	0.51	58.29	88.63
subsurface	N/A	N/A	1.25	8.3	4.14	7.51	1.09	37.45	2.04	10.79	0.53	39.75	89.08
River Ponds [6]	N/A	N/A	As allowed by RAP Section 4.3.2.(3), no soil sampling required as area excavated below water table										
Club Mesa Spray Area	N/A	7.1	As allowed by RAP Section 4.5.2.(3), no soil sampling required as area excavated to bedrock										
A-Plant, surface	15.8	4.2	2.5	2.7	6.9	2.4	0.3	7	0.7	5	0.2	63.8	21
subsurface	N/A	N/A	3.1	4.7	12.2	2.9	0.3	9	1	5	0.2	72.3	26
A-Plant North, [6] surface	19.5	3.7	2.54	5.36	12.35	6.54	0.50	11.15	1.00	6.71	0.76	48.77	30.00
subsurface	N/A	N/A	2.88	5.27	11.68	6.19	0.50	10.18	1.00	6.86	0.84	40.87	25.43
B-Plant, [7] surface	28.8	13.4	8.6	13.5	22.1	7.7	0.6	8.6	1.4	3.6	0.7	86.3	17.4
subsurface	N/A	N/A	8.3	9.6	9.5	33.3	0.2	12.3	5.7	18	1.2	79.8	29
Historic Structures Area	16.0	3.2	No soil samples were collected in this area, however direct measurements have shown that it meets RAP criteria.										
Windblown Area, Area E, [8] surface	16.1	N/A	6.9	13.8	25.4	4.5	0.5	14	ND	5.3	0.5	111.7	46.3
Mill Hillside, [8] surface	35.1	22.0	17.1	22.6	60.6	7.2	0.5	12.8	1.4	20.3	1.8	194.3	39.5
subsurface	N/A	N/A	10.5	12.7	33.3	6.3	0.3	8.8	1.1	10	1.3	124	31
County Road Y-11	N/A	4.5	No soil samples were collected in this area										
County Road EE-22 [9], surface	18.2	4.9	29.6	39.3	58.4	8.2	0.5	22.1	1.5	5	3	259	43
subsurface	N/A	N/A	29.2	39.6	59.2	9.2	0.7	49	1.3	6	2	320	39.8
Water Storage Ponds, surface	15.7	3.0	2.3	2.8	6.7	6.5	ND	8.8	1.1	4.9	ND	35	26
subsurface	N/A	N/A	1.8	1.7	5	6.3	ND	7.7	1.1	5	ND	29	27
Town Area, surface	16.9	4.3	2.9	4.9	10.2	7.4	0.6	38	1.6	8	1.2	45	129
subsurface	N/A	N/A	2.9	4.7	8.7	7.6	0.6	41	1.6	6	1	40	118

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Exhibit 6-1 Summary of Soil Cleanup Objectives, Average Residual Contaminant Values, and Exceedances in Soil (continued)

Description	One-Meter Gamma Exposure Rate, Average µR/hr	Surface Soil Radium-226 Concentration, Average pCi/g	Radium-226 pCi/g	Thorium-230 pCi/g	Natural Uranium mg/kg	Arsenic mg/kg	Cadmium mg/kg	Lead mg/kg	Molybdenum mg/kg	Nickel mg/kg	Selenium mg/kg	Vanadium mg/kg	Zinc mg/kg
Average Residual Concentration by Remediation Area[10]													
Atkinson Creek Streambed	N/A	N/A	1.9	2.5	2.8	7	1	6.1	2	3.9	0.8	18.3	33.4
Hieroglyphic Canyon Streambed	25.5^	13.8	No confirmation investigation necessary as remedial activities performed as prescribed in *Materials Identification and Removal Plan*										
Northeast Highway 141 including Right of Way, surface	16.9	8.0	4.4	6	8.1	5.8	0.36	19.8	0.89	4.5	0.41	28.2	45.5
subsurface	N/A	N/A	2.8	4	5.3	6	0.3	15.3	0.92	5.2	0.24	23.1	44.7
CDOT Highway 141, subsurface	17.9	4.1	3.1	4.1	8.5	8.8	0.7	16.7	1.3	5.5	0.2	40	55.7
Town Dump, surface	13.8	2.5	1.4	3.2	6.1	5.1	ND	9.7	1.6	6.5	ND	32	29
subsurface	N/A	N/A	1.8	2.6	5.8	5.5	ND	11	1.8	6.7	ND	32	31

Key:

Category 1 Exceedance Category 2 Exceedance

Notes:

1. The information summarized in this table is from the Compliance Reports provided by CDPHE.
2. Surface cleanup criteria i.e. 0 to 15 centimeters
3. Subsurface cleanup criteria i.e. > 15 centimeters
4. See Table 2-3 in Site-Specific Soil Cleanup Objectives Rationale Document for Uravan Project, Colorado, dated June 1999.
5. The have been calculated from information given in Potential Health Significance of Residual Levels of Metals in Soils at the Atkinson Creek Crystal Disposal Area, Uravan, Colorado, Revision 1, dated April 12, 1994 to be consistent with the results provided in other reclamation area confirmation reports.
6. Alternate Soils Standards have been approved for the River Ponds, A-Plant North, the Mill Hillside, and County Road Y-11.
7. The B-Plant area will be transferred to the Department of Energy for long-term stewardship and will effectively restrict future use of the land and minimize future exposure.
8. Soils samples were only collected in Area E. Since sampling for windblown, only surface soil samples were collected. Laboratory analyses indicate that soils are NORM rather than windblown licensed materials.
9. Soil samples collected on September 15 – 17, 1998, as part of characterization investigation. Additional sampling not conducted after remedial activities as roadway was immediately backfilled with clean materials so that road traffic could be maintained in accordance with Montrose County requirements. CDPHE inspected excavated area and confirmed that all tailings material were removed.
10. Confirmatory Soil samples were collected on a 10 x 10-meter grid basis. Surface Soil= 0-15 cm, Subsurface Soil= 15-30 cm
11. Regional Screening Levels (RSLs) are based on EPA 2014 exposure assumption recommendations which vary from those used in the 1999 RSL table; in addition, toxicity values and/or relative bioavailability default values have been updated since 1999. Exposure pathways include: ingestion, dermal contact, and inhalation of particulates.
12. The PRG table values were released in 2014 and do not reflect December 2016 changes to PRG equations. Residential exposure pathways include: external exposure, ingestion, inhalation, and ingestion of fruits and vegetables. EPA 40 CFR 192: The concentration of radium-226 in land averaged over 100 m2 shall not exceed the background level by more the 5 pCI/g averaged over the first 15 cm of soil below the surface, and 15 pCI/g averaged over 15 cm thick layers of soil more than 15 cm below the surface.
13. Because the RSL for arsenic is below background; the background value is considered the appropriate value for IC determination.

* = Distance along streambed centerline.

^= The RAP Sections 4.7.2.4.1, 4.7.2.5.2 and 4.7.2.5.3 requires cleanup of Windblown Area, Atkinson Creek, and Hieroglyphic Canyon that are “concentrated, contaminated deposits” with exposure rates greater than 30 µR/hr. These results are from the characterization surveys as either no remediation or only limited prescriptive remediation was performed and as such no confirmation investigation was completed as noted in the Compliance Reports.

RAP = Remedial Action Plan, N/A =Not Applicable/ Not Available, µR/hr = microroentgens per hour, mg/kg= milligrams per kilogram, ND= Not Detected, NORM= Naturally-Occurring Radioactive Materials, pCi/g = picocuries per gram

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Maximum discrete confirmation samples were also compared with soil cleanup objectives. Exhibit 6-2 shows a summary of discrete contaminant exceedances in soil.

Exhibit 6-2 Summary of Discrete Residual Contaminant Exceedances in Soil

Remediation Area	Restored Surface	COCs that exceed 1999 Site Specific Soil Cleanup Objectives Rationale Document Criteria		
		Category 1 RAP Criterion[1]	Category 2 Residential Land Use	Category 3 Dose/Risk Based[2]
Atkinson Creek Crystal Disposal Area[3]	Soil cover	Ra-226, Th-230, As, Mo, V	Ra-226, As	None[2]
Club Ranch Ponds[3]	Soil and rock cover	Ra-226, Th-230, As, Cd, Mo, U, V	Ra-226, Th-230, As	None[2]
Club Mesa Area	Soil and rock cover	Ra-226, Th-230, U	Ra-226	None
A-Plant[6]	Rock mulch and rubble cover	Ra-226, Th-230, Mo, U, V	Ra-226, Th-230	None
A-Plant North	Rock mulch and rubble cover	Ra-226, Th-230, U, V	Ra-226, Th-230	None
B-Plant	Rock mulch and rubble cover	Ra-226, Th-230, As, Mo, U, V	Ra-226, Th-230, As	None[2]
Town Area[3]	Graded and revegetated	Ra-226, Th-230, As, Cd, Mo, Pb, U, V, Zn	Ra-226, Th-230, As, Pb	None[2]
Town Dump	Graded and revegetated	Th-230, Mo, U, V	Th-230	None
Windblown Area E	N/A	Ra-226, Th-230, U, V	Ra-226, Th-230	None
Mill Hillside	Rock cover	Ra-226, Mo, U, V	Ra-226, U, V	None
County Road Y-11	Backfilled and road surface cover	Ra-226	Ra-226	None
Water Storage Ponds	Soil Cover	Ra-226, Th-230, Mo, U, V	Ra-226, Th-230	None
Northeast Side Highway 141	Soil and rock cover	Ra-226, Th-230, U, V	Ra-226	None
CDOT Highway 141 Mileposts 75-76[4]	Soil cover	Ra-226, Th-230, Mo, U, V	Ra-226	None
Nature Conservancy Visitor's Site	Soil cover (with cobbles)	Ra-226, Th-230, U	Ra-226, Th-230	None

Notes: 1. RAP Table 4.1.2.1 Criterion 2 (Umetco 2005).
2. Category 3 standards for arsenic are area-specific and were not established for the area.
3. In March 2017, Colorado Department of Public Health and Environment consulted with Nuclear Regulatory Commission regarding 242 grids (10 meters by 10 meters) of elevated radium concentrations, which could affect the results presented. These grids have radium concentrations between 7.1 and 58 pCi/g, but still meet the Category 3 standard of the 1999 soil methodology document (Umetco 1999a). These areas include Atkinson Creek Disposal Area, Part of Club Ranch Ponds, A-Plant North outside of the original alternative soil standard area, County Road EE-22, and the Town Area. NRC requested an alternative soil standards application to be submitted to NRC for five areas containing these grids. CDPHE and Umetco is currently preparing an alternative soil standards application for submittal to NRC for approval.
4. Deleted from the national priority list on September 4, 2007.
As = arsenic, Cd =cadmium, CDOT = Colorado Department of Transportation, COC = Contaminants of Concern, Mo = molybdenum, N/A = not applicable, Pb = lead, pCi/g = picocuries per gram, Ra = radium, RAP = Remedial Action Plan, Th = thorium, U = uranium, V = vanadium

6.1.1.1 Residual Risks Associated with Solids

EPA developed a memorandum that evaluated residual risks associated with various remediation areas at the Site. The purpose of the evaluation was to determine the contemporary validity of the radiation and chemical risk assessments conducted as part of the response action; to determine whether the actions taken by Umetco are sufficiently protective of human health and the environment using current CERCLA risk assessment methodologies; and to make recommendations on which remediation areas with residual contamination may require additional remedial components (e.g., land use controls) to be sufficiently protective of human health and the environment (EPA 2017). Recommendations and summary of results from the risk evaluation are provided in Section 6. The residual risk evaluation memorandum is provided in Appendix G.

Significant Radionuclide and Gamma Exposure Rate - Risk Calculations for the CSM

The risk assessment calculated the radionuclide carcinogenicity risk for residual radioactive contamination present in the various remediation areas at the Site using two difference methods. The first method applied the Conceptual Site Model (CSM) and risk assessment approach (Umetco 1999a). The second method used the EPA PRG Calculator and select exposure time and duration values from the CSM. The radionuclide carcinogenicity risks were calculated for worker, rancher, recreational user, and, where potential exists for land usage or zoning changes, resident exposure scenarios. The protective risk range that is acceptable for any CERCLA exposure scenario is 1E-04 to 1E-06 excess cancers, with the point of departure at the lower end of the risk range.

For the first method using the CSM and risk assessment approach, the evaluation findings included:

- Rancher exposure scenarios are below 1E-06 excess cancer risk for areas outside the future DOE transfer boundary.
- Excess cancer risk for recreational exposure scenarios are within the 1E-05 to 1E-06 risk range outside the future DOE transfer boundary.
- Occupational exposures are expected to fall in within the 1E-05 to 1E-06 excess cancer risk range outside the future DOE transfer boundary.
- Residential exposures were evaluated only for the Atkinson Creek Crystal Disposal Area and the Hieroglyphic Canyon Streambed. In these instances, the risk ranged from 3.39E-05 at Atkinson Creek to 1.30E-04 at Hieroglyphic Canyon.

For the second method using the EPA PRG Calculator and select exposure time and duration values from the CSM, the evaluation findings included:

- Rancher exposures and recreational exposures, which include a fractional contaminated beef consumption risk factor, are all less than 8.63E-06 for excess cancer risk.
- Occupational exposures are expected to be less than 1E-06 excess cancer risk at all the remediation areas expected to transfer to DOE LM.

- Residential exposures were evaluated only for the Atkinson Creek Crystal Disposal Area and the Hieroglyphic Canyon Streambed. In these instances, the excess cancer risk ranged from 2.03E-05 at Atkinson Creek to 9.06E-05 at Hieroglyphic Canyon (EPA 2017).

Significant Radionuclide and Gamma Exposure Rate - Dose Calculations for the CSM

Potential radiation dose calculations were performed using maximum grid and average residual contamination values for Ra-226 in each remediation area, with dose conversion factors and the CSM values to calculate doses for the various exposure scenarios (Umetco 1999a). ICs would restrict any potential residential development of the remediation areas, especially Hieroglyphic Canyon and Atkinson Creek Streambed, the calculations of potential doses indicate that recreational, rancher, and occupational exposure scenarios are sufficiently protective. The dose calculation evaluation findings included:

- Effective dose equivalents for occupational exposures to residual Ra-226 contamination on all the remediation areas expected to transfer to DOE LM is expected to fall within the range of 7 mrem/year to 1,816 mrem/year.
- Dose for recreational and rancher exposures, ranged from 0 to 87 mrem/year.
- Doses associated with residential exposures were evaluated only for the Atkinson Creek Crystal Disposal Area and the Hieroglyphic Canyon Streambed. In these instances, the effective dose equivalent ranged from 129 to 2,245 mrem/year at Atkinson Creek and 377 to 404 mrem/year at Hieroglyphic Canyon (EPA 2017).

Chemical Exposure Risks

To evaluate the non-carcinogenic residual risk, the Hazard Index (HI) for the various routes of exposure in the CSM for each remediation area. Hazard indices were calculated using the EPA RSL Calculator and the residual soil concentrations for the metal contaminants of concern. The evaluation findings included:

- Occupational exposures to residual metals contamination on all the remediation areas expected to transfer to DOE LM are below 0.00606 for expected adult exposure scenarios.
- Recreational exposures, for child and adult, ranged from 0.00197 to 0.185.
- Residential exposures, for child and adult, were evaluated for the Atkinson Creek Crystal Disposal Area and the Hieroglyphic Canyon Streambed, as well as all the areas where ranching is anticipated to occur.
    - In all these instances, the adult non-carcinogenic HI for metals exposure ranged from 0.0247 to 0.435.
    - For the child non-carcinogenic HI for metals exposure, the HI ranged from 0.0262 to 4.63. The HI for child residential metals exposure exceeded 1 on the Windblown Area (1.92) and County Road EE-22 (4.63) (EPA 2017).

6.1.2 Liquids

A summary of the liquid remedial activities is provided in the following subsections.

6.1.2.1 Hillside Seepage and Tailings Liquids

Seepage had been occurring intermittently along approximately 4,600 linear feet of the Club Mesa rim. Seepage occurred near the contact between the Summerville and Salt Wash Formations and exits the valley walls of Hieroglyphic Canyon and the San Miguel River above the A-Plant Area. The seepage was composed of geochemically modified tailings solutions from the Club Mesa Tailings Piles and the Club Mesa Spray Area (EPA 2015).

Umetco improved the Hillside Seepage Collection System in 1998. Seepage collection was completed by 2003 and the system was decommissioned. Decommissioning included sealing the toe drain system and placement of rock rubble to prevent erosion (EPA 2015).

6.1.2.2 Ponded Liquids and Surface Runoff

Contaminated liquids were contained in various ponds around the mill and within the mill circuit. By May 31, 1988, all collected fluids from mill circuit, hillside seepage, and toe berm collection systems and the surface runoff collection systems were being pumped into the new lined evaporation pond, CRP-7. On Apri1 30, 2003, Umetco notified CDPHE that the remediation of all waste material was complete and the placement of the reclamation covers on the Tailings Piles was complete. All the runoff control ponds were removed during the second quarter of 2003 (CDPHE 2015a).

6.1.2.3 Surface Water

The trend plot for TDS indicates an overall decrease in TDS concentrations at Station 5 (downstream) over the last five years. This decrease is consistent with the lower concentrations observed at Station 1 (upstream). The trend plot for un-ionized ammonia shows that there is some continuing contribution from the groundwater plume beneath the former Club Ranch Ponds as increases in concentrations occur between Station 4 and Station 5, but that the concentration continues to decrease and remains well below the water quality standard for the San Miguel River of 0.06 milligrams per liter (mg/L). The plots for TDS, calcium, and magnesium show that the water chemistry remains very similar from upstream to downstream of the Site.

The post-operational surface water monitoring set forth in the CDPHE-approved Application for Alternate Concentration Limits, Uravan Project Site was completed in 2006. However, monitoring will continue in anticipation of the DOE continuance of surface water monitoring under the Long-Term Surveillance Program. As indicated in the 2016 Annual Uravan Report, there is no significant impact on the river system since the evaluated analytes at Station 5 are below applicable standards (Umetco 2017).

6.1.2.4 Groundwater

Umetco installed a groundwater extraction system in 1991 and upgraded it in 1996 and 1998. Groundwater pumping began in 1991 and resulted in removal of approximately 15,000 tons of contaminants. The RAP required extraction and evaporation of Kayenta-Wingate groundwater in the CRPs Area. The goal of the RAP activities for Kayenta-Wingate Aquifer restoration was to remove and manage fractured bedrock contamination and improve groundwater in the Kayenta-

Wingate Formation to a beneficial use. As stated in the RAP, achieving this goal, coupled with the removal of raffinate crystals and ponded liquids from the San Miguel River valley, substantially reduced the contaminated non-point load to the river (EPA 2015).

In 2003, ACLs were proposed for 11 constituents for contaminated groundwater at the Site. These ACLs were developed in accordance with the RAP and CDPHE Radioactive Materials License 660-02, and were approved by CDPHE and EPA in 2003 (CDPHE 2003). The groundwater evaluation required by the ACL application expired in 2006, but has been continued in anticipation of the DOE maintaining this evaluation under the Long-Term Surveillance Program. Groundwater monitoring conducted in the Club Ranch Ponds area continues to demonstrate that ACLs for constituents of concern were met during post-operational monitoring established in the ACL application (Umetco 2017). It should be noted that CERCLA ACLs for groundwater have not been identified for this Site. EPA supports the decision for the use of State ACLs for this Site. Monitoring of groundwater to confirm that ACLs are protective of human health and the environment is ongoing (Umetco 2017).

6.2 Recommendations

The findings as described in this RI report are consistent with previous RA reporting that contaminated soil and groundwater remain at the Site above levels to allow unlimited use/unrestricted exposure, as indicated in the *Review of Umetco Risk Assessment, Alternative Soils Standards, and Residual Contamination* (EPA 2017). In addition, capped on-site repositories, subsurface soil remaining in place above site-specific soil cleanup objectives (beneath restored surfaces) and groundwater concentrations (i.e., use of ACLs) are all examples where restrictions are needed.

These findings support the proposition that additional remedial components, that may include land use controls/institutional controls, should be implemented at the Site after the CDPHE Radioactive Materials License 660-02 for the Site is terminated which is also consistent with the findings from the previous five-year review (EPA 2015), as well as findings from the risk assessment evaluation (EPA 2017). These additional remedial components are considered an element of the selective remedy to ensure long-term protectiveness and will be evaluated further in the FFS for incorporation into the proposed plan and final ROD.

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Section 7
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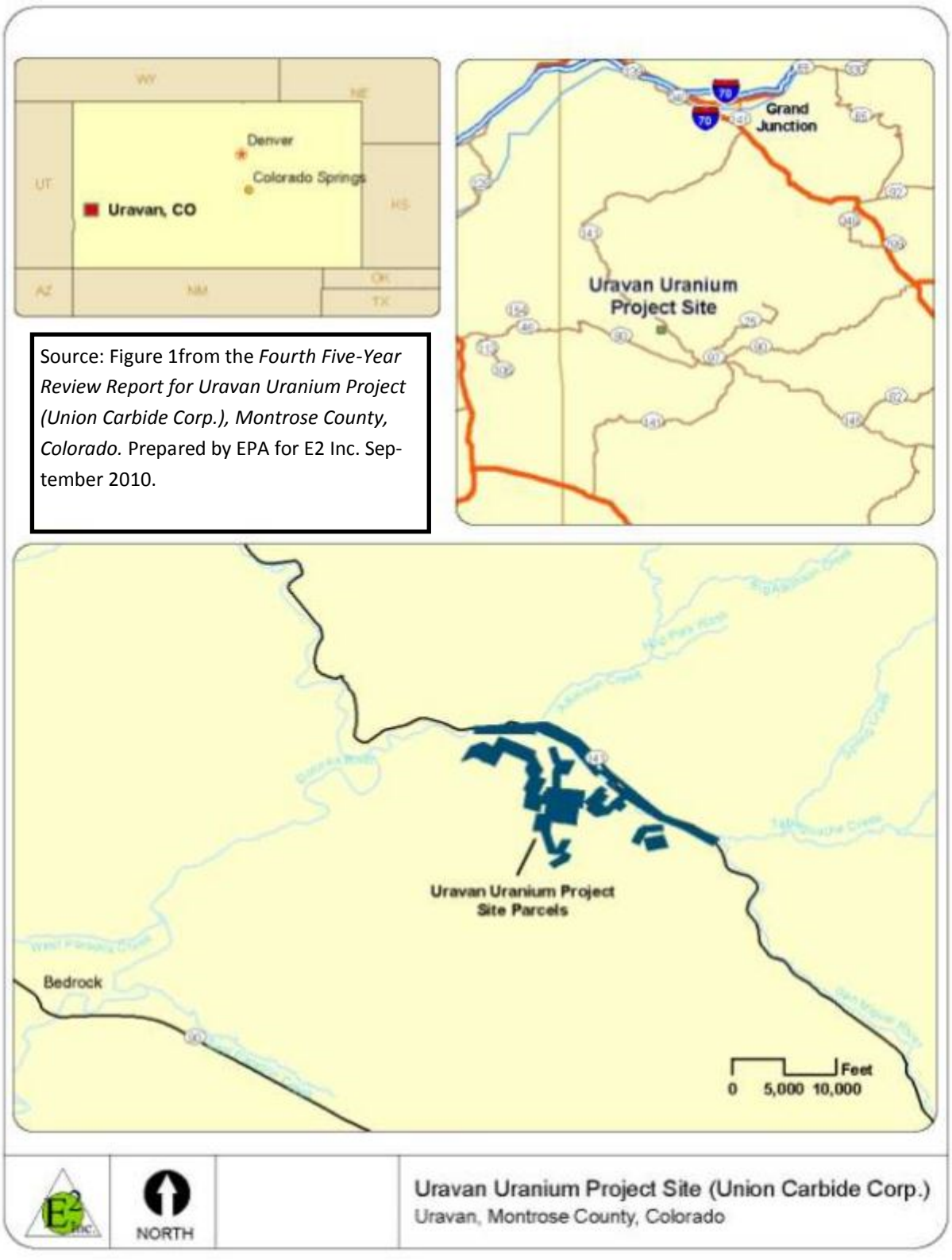
Figures



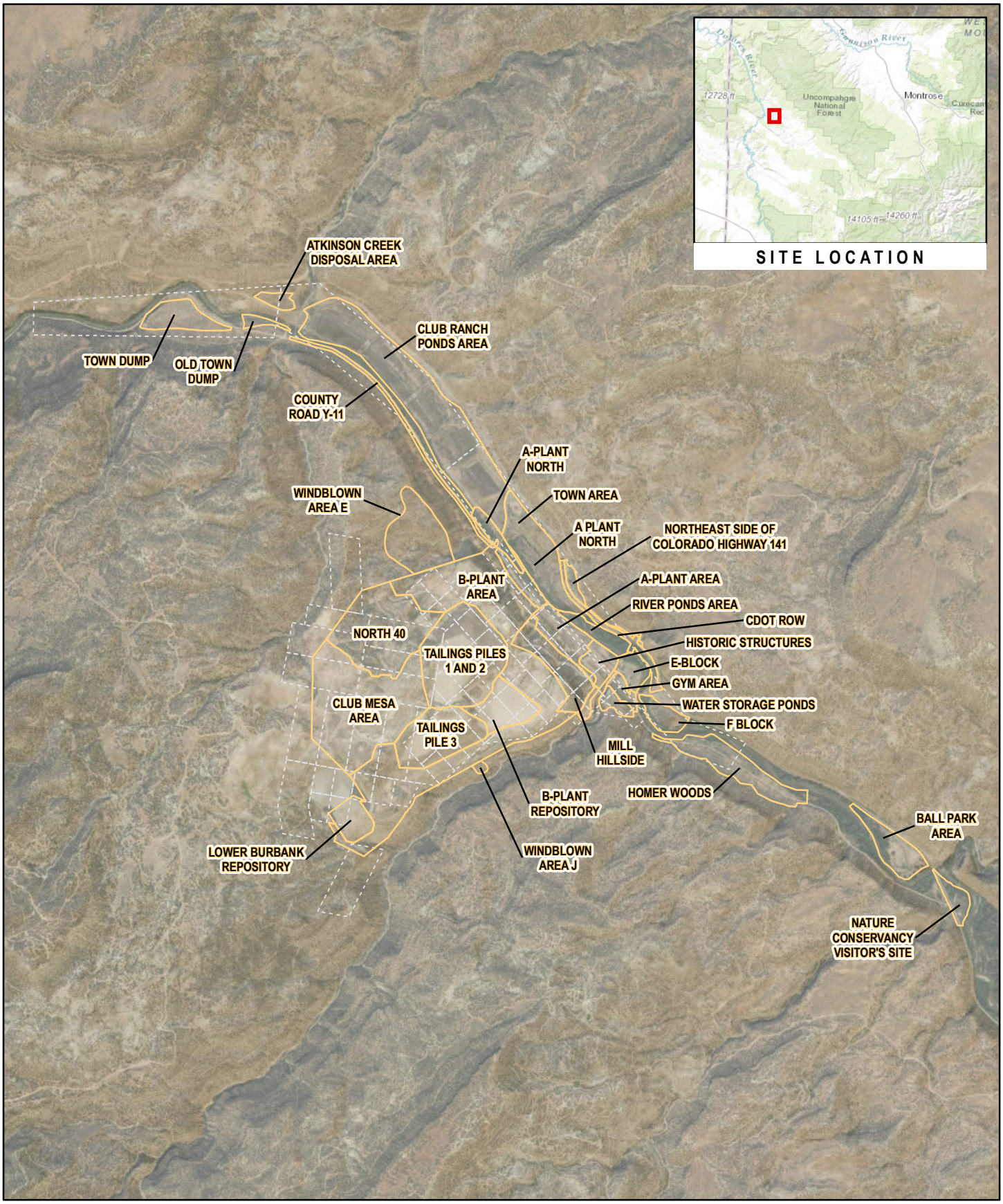
Source: Figure 1from the *Fourth Five-Year Review Report for Uravan Uranium Project (Union Carbide Corp.), Montrose County, Colorado.* Prepared by EPA for E2 Inc. September 2010.

Disclaimer: This map and any boundary lines within the map are approximate and subject to change. The map i p is for informational purposes only regarding EPA's response actions at the Site, and is not intended for any other purp

Figure 1-1

Location Map

Uravan Uranium Project, Uravan, Colorado



N

0 0.25 0.5 1 Miles

1 inch = 0.5 miles

Site Area Boundary

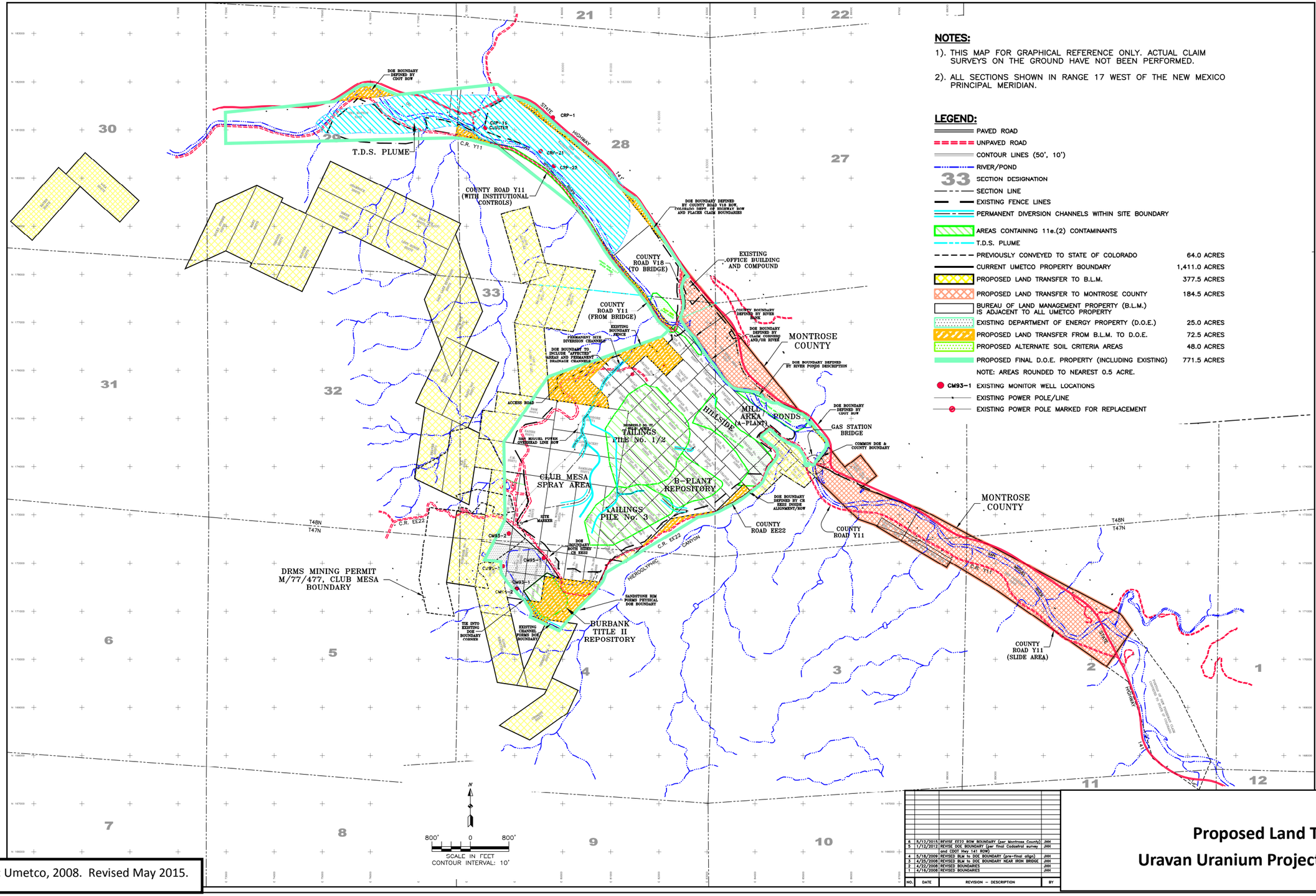
Claim Boundary

Service Layer Credits: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community; Sources: Esri, USGS, NOAA; Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Figure 1-2 **| Site Area Boundaries and Nomenclature**
Uravan Uranium Project, Uravan, Colorado

CDM Smith
555 17th Street
Suite 500
Denver, CO 80202
Tel: (303) 383-2300

Document Path: T:\79171_Uravan\MXD\SiteOverview_v2.mxd Date Saved: 8/30/2017 Author: WAGNERA CDMSmith

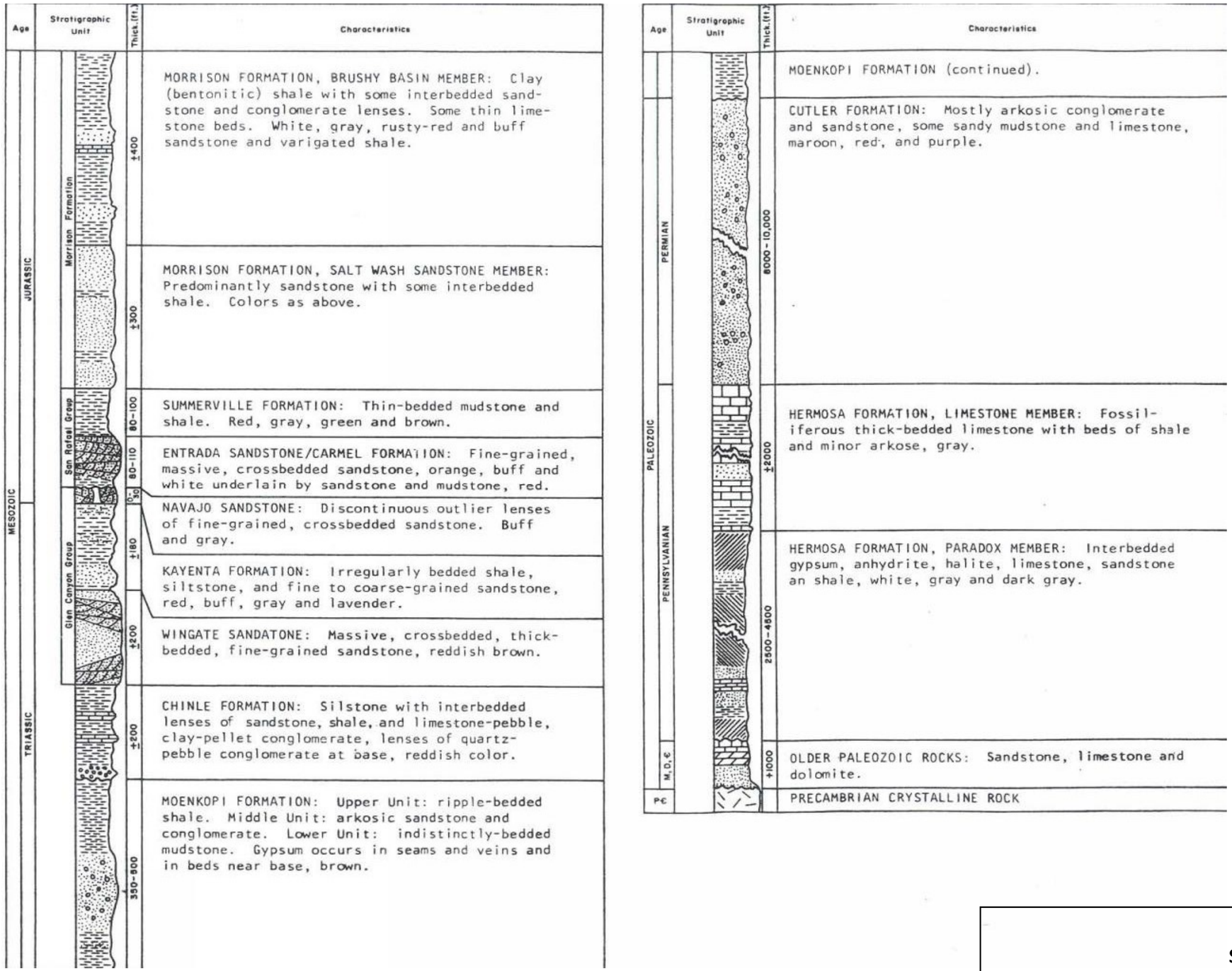


Source: Umetco, 2008. Revised May 2015.

Figure 2-1

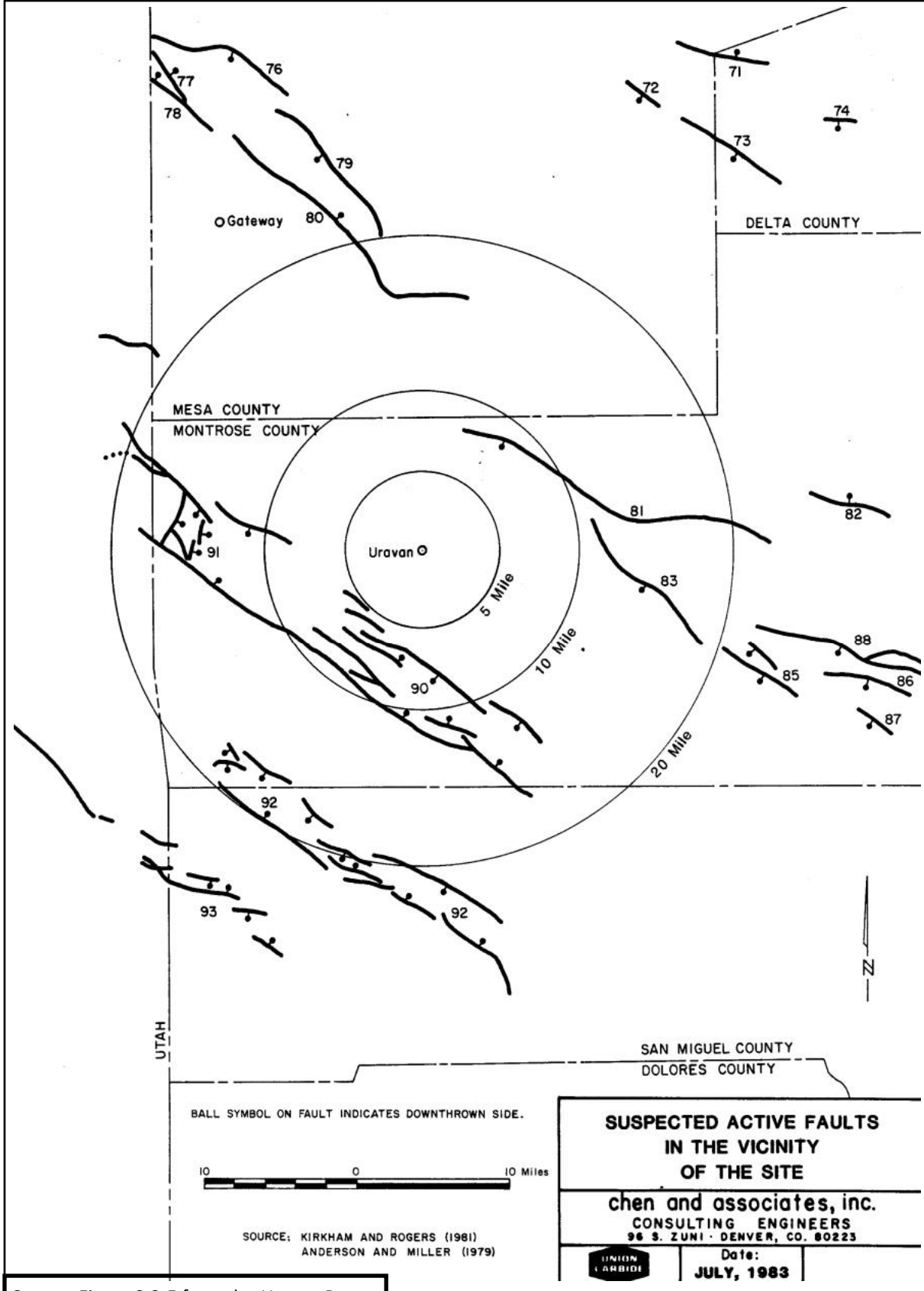
Proposed Land Transfer Boundaries

Uravan Uranium Project, Uravan, Colorado



Source: Figure 2.3-1 from the *Uravan Remedial Action Plan (RAP): (With tracking of changes 1986-2005).*, CDPHE May 2005.

Figure 2-2
Stratigraphic Column of the Uravan Area
Uravan Uranium Project, Uravan, Colorado



Source: Figure 2.3-5 from the *Uravan Remedial Action Plan (RAP): (With tracking of changes 1986-2005).*, CDPHE May 2005.

Figure 2-3

Suspected Active Faults near Uravan

Uravan Uranium Project, Uravan, Colorado