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SLICK ROCK, COLORADO

August 1994

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UMTRA PROJECT
WATER SAMPLING AND ANALYSIS PLAN
SLICK ROCK, COLORADO

August 1994

Prepared for
U.S. Department of Energy
UMTRA Project Office
Albuquerque, New Mexico

Prepared by
Jacobs Engineering Group Inc.
Albuquerque, New Mexico

EXECUTIVE SUMMARY

This water sampling and analysis plan (WSAP) provides the regulatory and technical basis for ground water and surface water sampling at the Uranium Mill Tailings Remedial Action (UMTRA) Project Union Carbide (UC) and North Continent (NC) processing sites and the proposed Burro Canyon disposal site near Slick Rock, Colorado for the upcoming year. It identifies and justifies the sampling locations, analytical parameters, and sampling frequencies. The WSAP bridges water quality characterization and data collection objectives for the surface remediation program (Subpart A) and the ground water compliance program (Subpart B) identified in 40 CFR Part 192 (1994).

Water sampling was conducted at the former Slick Rock UC and NC processing sites in February 1994 and at the proposed Burro Canyon disposal site in April 1994. Ground water, surface water, and sediment sampling were conducted at the processing sites 1) to ensure protection of human health and the environment, 2) to define the nature and extent of contamination, 3) for ground water compliance monitoring prior to surface remedial action, and 4) for a baseline risk assessment of ground water contamination at the former processing sites. Ground water sampling was conducted to establish background ground water quality conditions at the proposed Burro Canyon disposal site.

The monitor well locations provide a limited distribution of sampling points to characterize ground water quality and ground water flow conditions in the vicinity of the sites. The list of analytes has been modified over time to reflect constituents that are related to uranium processing activities and the parameters needed for geochemical evaluation for the surface remedial action and ground water compliance programs.

Water sampling is expected to continue on an annual basis (February/March time frame) at the processing sites in 1995. Water sampling at the proposed Burro Canyon disposal site is contingent on resolution of the preliminary final surface remedial action plan (RAP) (DOE, 1994). The RAP was being reviewed by the U.S. Nuclear Regulatory Commission and the Colorado Department of Public Health and Environment at the time of publication of this document.

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LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
ac	acre
ASER	Annual Site Environmental Report
BLM	Bureau of Land Management
CDPHE	Colorado Department of Public Health and Environment
cm	centimeter
cm/s	centimeters per second
DCO	data collection objective
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FBDU	Ford, Bacon, and Davis Utah Inc.
ft	foot
ft/yr	feet/year
gpd	gallons per day
ha	hectare
kg	kilogram
km	kilometer
L/s	liters per second
LTSP	long-term surveillance plan
m	meter
m ³	cubic meter
MCL	maximum concentration limit
mg/L	milligrams per liter
mi	mile
MSL	mean sea level
NC	North Continent
NRC	U.S. Nuclear Regulatory Commission
ORP	oxidation-reduction potential
pCi/L	picocuries per liter
POC	point of compliance
QA	quality assurance
QC	quality control
RAP	remedial action plan
RRM	residual radioactive material
SOP	standard operating procedure
TDS	total dissolved solids

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

<u>Acronym</u>	<u>Definition</u>
UC	Union Carbide
Umetco	Union Carbide Corporation
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
WSAP	water sampling and analysis plan
yd ³	cubic yard

1.0 INTRODUCTION

1.1 PURPOSE

This water sampling and analysis plan (WSAP) provides the regulatory and technical basis for ground water and surface water sampling at the designated Uranium Mill Tailings Remedial Action (UMTRA) Project Union Carbide (UC) and North Continent (NC) processing sites and the proposed Burro Canyon disposal site near Slick Rock, Colorado. It identifies and justifies the sampling locations, analytical parameters, and sampling frequencies. The ground water and surface water data are used to ensure protection of human health and the environment, for site characterization, for compliance monitoring, and for a baseline risk assessment of ground water contamination at the former processing sites.

Ground water and surface water monitoring activities are based on the U.S. Environmental Protection Agency (EPA) regulations in 40 CFR Part 192 (1994) and the proposed EPA standards of 1987 (52 FR 36000 (1987)), UMTRA Project standard operating procedures (SOP) (JEG, n.d.), the *Technical Approach Document* (DOE, 1989), the *Guidance for Implementing the UMTRA Project Long-term Surveillance Program* (DOE, 1992), and the most effective technical approach for the site based on hydrogeologic characterization and historical water quality and water level data.

This WSAP summarizes the results of previous water sampling activities and the plan for water sampling activities to be conducted in the upcoming year.

1.2 SITE LOCATION

The designated UMTRA Project Slick Rock UC and NC uranium mill tailings sites are located near the small town of Slick Rock in San Miguel County, Colorado (Figure 1.1). Both sites are adjacent to the Dolores River. The UC site is approximately 1 mile (mi) (2 kilometers [km]) downstream from the NC site. Contaminated materials, such as tailings and windblown and waterborne residual radioactive materials (RRM), cover an estimated 55 acres (ac) (22 hectares [ha]) at the UC site and 12 ac (4.9 ha) at the NC site. The UC site contains the former mill building concrete foundation, tailings piles, demolition debris, and areas contaminated by windblown and waterborne RRM. The total estimated volume of contaminated materials is approximately 618,700 cubic yards (yd³) (472,700 cubic meters [m³]). Water quality monitoring, conducted at the Slick Rock processing sites since 1986, indicates that contamination associated with the UC and NC sites has leached into the ground water (DOE, 1994).

The proposed surface remedial action consists of relocating, disposing, and stabilizing the contaminated materials from the former processing sites into a permanent repository at the proposed Burro Canyon disposal site, approximately 6 road mi (10 km) northeast of the mill sites (Figure 1.1) on land currently administered by the Bureau of Land Management (BLM).

FIGURE 1.1
LOCATION OF PROCESSING AND DISPOSAL SITES,
SLICK ROCK, COLORADO

The U.S. Department of Energy (DOE) is responsible for demonstrating that cleanup or control of existing processing-related ground water contamination at the designated Slick Rock processing sites complies with the proposed EPA ground water protection standards in Subpart B of 40 CFR Part 192 (1994). The DOE has decided that ground water compliance will be addressed under a separate DOE program, which will comply with the National Environmental Policy Act. Investigations will be conducted as necessary to determine the appropriate ground water compliance strategy.

1.3 SITE HISTORY

Both the NC and UC sites are currently owned by the Union Carbide Corporation (Umetco). The NC site dates to 1931, when it was owned by the Shattuck Chemical Company. North Continent Mines Inc. acquired the site in 1934. The milling process extracted vanadium oxide, uranium, and a radium concentrate from the host rock by a complex chemical leaching and precipitation process. When the mill was upgraded in 1942, mill capacity increased to 30 tons (30,000 kilograms [kg]) per day from the initial capacity of 10 to 15 tons (9,000 to 14,000 kg) per day (FBDU, 1981).

Title to the NC mill passed to several companies until the federal government, through the Union Mines Development Corporation, acquired control of the site specifically to supply uranium and vanadium for the Manhattan Project. Umetco became owner of the NC site in 1957.

An estimated 37,000 tons (34×10^6 kg) of ore were processed during the mill's lifetime, producing the same amount of tailings. An estimated 84,800 yd³ (64,800 m³) of contaminated materials covering 12 ac (4.9 ha) are present on-site (FBDU, 1981). All structures were removed after milling operations were discontinued in the early 1960s. When the mill was dismantled, bricks removed from the roaster were buried in the tailings pile. The pile was contoured, covered with 6 inches (15 centimeters [cm]) of soil, and vegetated. Seepage from the NC tailings pile has entered the ground water in the alluvium beneath the site.

The UC mill began operation in 1957 with a design capacity of 350 tons (320,000 kg) per day and later expanded to 500 tons (450,000 kg) per day, processing ore mined from the Slick Rock area (FBDU, 1981). The ore was processed into three concentrates: the first was a dry-fine product, the second was produced from a slime concentrate processed with recirculated acid solution, and the third resulted from ammonia neutralization of part of the pregnant solution. All three products were shipped to Umetco's Rifle mill for additional processing. Sand tailings remaining at the site contain only a small portion of residual radioactivity.

The Slick Rock UC site ceased operations in December 1961. Except for some concrete foundations, all mill buildings have been removed from the UC site. A former recreational building and a dormitory remain adjacent to the UC site. The volume of tailings and contaminated materials are collectively estimated at 533,800 yd³ (407,800 m³) covering approximately 55 ac (22 ha). Most of this material (296,000 yd³ [226,000 m³]) is tailings. The remaining 237,800 yd³

(181,800 m³) consist of contaminated soils that were distributed either by wind or water. The tailings pile was contoured, covered with 6 inches (15 cm) of soil, and vegetated. The pile currently has vegetation covering 20 percent of the surface (FBDU, 1981). A small earth dike separates the pile from the Dolores River; however, the river has eroded the dike, affecting an estimated 25 percent of the stabilized pile and soil cover. Seepage from the UC tailings piles has also entered the ground water in the alluvium beneath the piles.

1.4 SITE STATUS

The following remedial activities have been proposed pursuant to the requirements of the Uranium Mill Tailings Radiation Control Act (UMTRCA) (42 USC §7901 *et seq.*) to satisfy the EPA standards in 40 CFR Part 192 (1994) for cleanup, stabilization, and control of the RRM:

- Contaminated material from both former mill sites will be relocated and buried in an engineered disposal cell approximately 6 road mi (10 km) northeast of the UC and NC processing sites in Sections 21 and 28, Township 24 North, Range 18 West (Figure 1.1). The partially below-grade disposal cell will cover approximately 12 ac (4.9 ha) (DOE, 1994).
- The need for a ground water compliance strategy will be considered in accordance with guidelines established in the draft programmatic environmental impact statement (DOE, 1994).

1.5 SAMPLING PLAN

Annual ground water sampling of selected DOE monitor wells and private wells at the Slick Rock UC and NC processing sites (SRK-01) was conducted in February 1994, and in April 1994 for the proposed Burro Canyon disposal site (SRK-02). These monitor well locations provide a limited distribution of sampling points to characterize ground water quality and flow conditions in the vicinity of the sites. The list of analytes has been modified over time to reflect constituents related to uranium processing activities, based on the site characterization information presented in the preliminary final *Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Sites at Slick Rock, Colorado* (DOE, 1994) (hereafter referred to as the RAP). Chemical constituents needed for geochemical evaluation are also analyzed to evaluate and distinguish between any natural trends in water quality relative to potential changes in water chemistry related to uranium processing activities.

In the upcoming year, water sampling is expected to continue on an annual basis (February/March time frame) at the Slick Rock sites. Future water sampling activities at the proposed Burro Canyon disposal site will depend on final resolution of the surface RAP. The preliminary final RAP for the Slick Rock UMTRA Project sites (DOE, 1994) is currently being reviewed by the U.S. Nuclear Regulatory Commission (NRC) and the Colorado Department of Public Health and Environment (CDPHE). The proposed plan for compliance monitoring at the disposal site is discussed in Section 3.2.2.

2.0 SLICK ROCK PROCESSING SITES

2.1 SITE CONCEPTUAL MODEL

The site conceptual model is based on available hydrogeologic information, site reconnaissance, and data from monitor wells installed in the alluvium, Entrada Formation, and the Navajo Sandstone (Figure 2.1 and Table 2.1). The conceptual model for the NC and UC processing sites is summarized below.

2.1.1 Physiographic setting

The designated Slick Rock processing sites are located within the deeply entrenched Dolores River valley at elevations of approximately 5500 feet (ft) (1700 meter [m]) above mean sea level (MSL) (Figure 2.1). The sites are located on gently sloping terrace surfaces dissected by small stream channels and gullies. Bedrock ridges and cliffs surrounding the river reach 6500 ft (2000 m) above MSL. The existing tailings piles are within the recent floodplain of the Dolores River. In their present locations, both piles are potentially subject to tailings dispersal caused by flooding (DOE, 1994).

2.1.2 Geology

Three hydrostratigraphic units underlie the UC and NC processing sites; they are surface deposits of Dolores River alluvium, underlain by the Entrada Formation (Slick Rock and Dewey Bridge Members) and the Navajo Sandstone. Figure 2.2 provides a geologic cross sectional view of the subsurface materials.

The Jurassic Summerville Formation crops out as canyon walls of the alluvial terraces surrounding the Dolores River floodplain, as shown in Figure 2.2. The Summerville consists of eroded layers of interbedded reddish-brown mudstones and siltstones, and some fine-grained sandstone, limestone, and shale; it is not considered to be a hydrostratigraphic unit that directly affects the UC or NC processing sites. The Dolores River meanders around these terraces. The Dolores River alluvium is composed of unconsolidated clayey sands, sandy gravels, and cobbles from the ground surface to an approximate depth of 20 ft (6 m) at both the UC and NC sites.

The Entrada Formation underlies the Dolores River alluvium and crops out in the area of both tailings piles. Two members of the Entrada Formation are present: the Slick Rock Member and the Dewey Bridge Member which dip toward the northeast. The Slick Rock Member underlies the Summerville Formation and alluvial deposits at the NC processing site and pinches out under the UC processing site. The Slick Rock Member is composed of eroded light brown fine-grained sandstone and reddish brown sandy shale. The Dewey Bridge Member underlies the Slick Rock Member at the NC processing site. At the UC site, where the Slick Rock Member is absent, the Dewey Bridge Member directly underlies Dolores River alluvium; it consists of reddish-brown clayey siltstone, fine-grained sandstone, and shale. The tops of the Dewey Bridge or Slick Rock

FIGURE 2.1
**WATER QUALITY SAMPLING LOCATIONS IN THE VICINITY OF THE NC AND UC PROCESSING SITES,
SLICK ROCK, COLORADO**

Table 2.1 DOE monitor well information for the NC and UC processing sites, Slick Rock, Colorado

SITE: SRK01 SLICK ROCK (BOTH SITES)
REPORT DATE: 08/25/94

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0501	58537.7	63677.8	5454.80	22.00	8.000	5456.48	22.00	4.000	12.00	9.0	O	AL
0503	58246.7	63269.3	5457.90	27.00	8.000	5459.39	27.00	4.000	20.00	6.0	O	AL
0504	58094.9	63088.4	5448.50	19.00	8.000	5450.81	19.00	4.000	14.00	4.0	D	AL
0505	58621.3	60065.9	5436.40	19.00	8.000	5441.05	19.00	4.000	11.00	8.0	O	AL
0506	59877.7	58895.7	5431.10	21.00	8.000	5431.37	19.	4.000	12.00	7.0	D	AL
0507	60019.9	58704.2	5431.50	20.00	8.000	5433.06	20.00	4.000	10.00	10.0	D	AL
0508	59547.6	59575.2	5437.30	20.00	8.000	5439.77	19.	4.000	12.00	7.0	O	AL
0509	59201.7	60131.0	5434.80	22.00	8.000	5436.80	22.00	4.000	12.00	10.0	O	AL
0510	59726.1	59228.0	5436.40	26.00	8.000	5438.59	24.	4.000	15.00	9.0	O	AL
0512	58394.2	63267.2	5450.40	20.00	8.000	5452.67	20.00	4.000	12.00	8.0	O	AL
0684	60988.0	58964.8	5430.20	23.00	6.000	5432.51	23.00	2.000	11.0	10.0	O	AL
0685	62187.5	58927.9	5426.30	27.00	6.000	5428.34	27.00	2.000	15.	10.0	O	AL
0686	58619.9	63769.6	5455.10	22.00	6.000	5457.29	22.00	2.000	15.	5.0	O	AL
0551	58464.81	58510.72	5524.49	80.00	8.000	5524.00	58.	4.000	46.	10.0	U	JE
0554	59171.94	58549.51	5500.87	50.00	8.000	5500.50	49.5	4.000	37.5	10.0	U	JE
0702	58881.87	59277.12	5489.55	70.00	8.000	5486.50	68.	4.000	55.	10.0	O	JE
0703	58719.29	58732.28	5522.34	55.00	8.000	5526.50	55.	4.000	41.8	10.0	O	JE
0704	59173.01	58879.14	5489.25	61.50	8.000	5491.67	60.	4.000	46.00	10.0	O	JE
0552	58480.06	58476.35	5524.82	80.00	8.000	5525.00	80.	4.000	68.	10.0	U	NA
0558	58131.86	58863.79	5524.79	82.00	8.000	5526.00	80.	4.000	68.0	10.0	U	NA
0668	58670.83	58711.47	5522.93	249.00	6.000	5524.91	153.0	2.000	111.	40.0	U	NA
0669	59555.2	59550.5	5438.80	107.00	6.000	5440.50	107.00	2.000	100.	5.0	U	NA
0670	59797.4	59171.8	5435.89	96.00	6.000	5437.76	96.00	2.000	84.	10.0	U	NA
0687	57223.2	62932.9	5492.80	195.00	6.000	5494.14	195.	2.000	173.	20.0	U	NA
0688	60020.8	57956.9	5453.60	70.00	6.000	5455.46	70.00	2.000	53.	15.0	U	NA

FORMATION OF COMPLETION CODE:

AL - ALLUVIUM
JE - JURASSIC ENTRADA SANDSTONE FORMATION
NA - NAVAJO SANDSTONE

FLOW RELATIONSHIP CODE:

O - ON-SITE
D - DOWN GRADIENT
U - UPGRADIENT

DATA FILE: \DART\SRK01\MWI10000.DAT

FIGURE 2.2
GEOLOGIC CROSS SECTION (NORTHWEST-SOUTHEAST)
OF THE NC AND UC PROCESSING SITES, SLICK ROCK, COLORADO

Members of the Entrada Formation were encountered beneath the alluvial deposits to depths ranging from 1 to 88 ft (0 to 27 m).

The Navajo Sandstone, composed of light-brown to reddish-brown fine-grained sandstone, underlies the Entrada Formation at depths between 53 and 173 ft (16 and 53 m) and also crops out upslope of the UC site. Because the bottom of the Navajo Sandstone was not encountered in any of the DOE borings, the thickness of the Navajo Sandstone has not been determined directly in the area of the Slick Rock processing sites. However, Shawe and others (1968) report the Navajo Sandstone ranges from 0 to 420 ft (128 m) thick in the Slick Rock area.

2.1.3 Hydrology

Ground water conditions at the Slick Rock processing sites are highly dependent on local structural, stratigraphic, and topographic features. Canyon cutting, tectonic fracturing, and discontinuities between the geologic formations are believed to have caused the distinct stratigraphic units (the Dolores River alluvium, Slick Rock and Dewey Bridge Members of the Entrada Formation and the Navajo Sandstone) to become hydraulically connected, based on lithologic log data and ground water levels. Ground water is unconfined in the alluvium. In the Entrada Formation, ground water is expected to be semi-confined when medium- to coarse-grained sediments are interbedded with clayey siltstones and shales; confining conditions are expected when only the low permeability siltstones and shales exist. In the Navajo Sandstone, ground water is expected to be semi-confined to confined; the relative amount of hydraulic connection between the Navajo and Entrada Formations is dependent on the permeability of the Navajo Sandstone and the overlying materials of the Entrada Formation, as well as on the variations in the contacts between the formations. Ground water elevations in the Dolores River alluvium, Entrada Formation, and the Navajo Sandstone have remained relatively constant and have not shown seasonal fluctuations (DOE, 1994).

- **Dolores River alluvium.** Depths to the water table at both processing sites range from 5 to 20 ft (2 to 6 m) in wells screened in the alluvium. Ground water flow in the alluvium is generally to the north (Figure 2.3). The average linear ground water velocity was estimated to be 100 feet per year (ft/yr) (0.97×10^{-4} centimeters per second [cm/s]) at the NC site, based on an average hydraulic conductivity of 23 ft per day (8.1×10^{-3} cm/s), a hydraulic gradient of 0.003, and an effective porosity of 0.25 for sand and gravel (DOE, 1994). At the UC site, the average linear ground water velocity was estimated to be 160 ft/yr (1.5×10^{-4} cm/s), based on an average hydraulic conductivity of 14 ft per day (4.9×10^{-3} cm/s), a hydraulic gradient of 0.008, and an effective porosity of 0.25. The Dolores River alluvium is recharged by the Dolores River upstream of the NC site and by precipitation. Ground water discharges from the alluvium into the Dolores River downgradient of both sites.
- **Entrada Formation.** In monitor wells screened in the Entrada Formation at the UC processing site, the depth to ground water is approximately 27 to 47 ft (8.2 to 14 m). Ground water elevations in the Entrada Formation are

FIGURE 2.3
WATER TABLE CONTOUR MAP FOR THE DOLORES RIVER ALLUVIAL WELLS,
NC AND UC PROCESSING SITES, SLICK ROCK, COLORADO

contoured in Figure 2.4 for October 1992. Since no monitor wells are screened in the Entrada Formation at the NC site, the information available for ground water movement in the Entrada Formation is limited. The potentiometric surface map for the UC site (Figure 2.4) suggests that ground water movement is generally to the east in the Entrada Formation; however, this representation may be biased by the limited number of monitor wells placed across a relatively small areal extent of the UC site (DOE, 1994). All of the Entrada wells are screened in the Dewey Bridge Member. The Entrada Formation is capable of functioning as a source of usable water, as evidenced by a gravity flow collector system tapping the Entrada on a canyon wall west of the UC processing site. Based on lithologic log data from wells drilled in the southwest portion of the UC site, a layer of sandy gravel approximately 25 ft (8 m) thick appears to have cut through the Slick Rock Member and eroded portions of the Dewey Bridge Member of the Entrada Formation. Hydraulic characteristics of the Entrada Formation have not been tested.

- **Navajo Sandstone.** In UC and NC monitor wells screened in the Navajo Sandstone, depths to ground water vary from 0 to 57 ft (17 m). Ground water elevations in the Navajo Sandstone Formation for October 1992 are contoured in Figure 2.5. The direction of ground water flow is generally to the north at both sites, however, some variability in the directions of horizontal and vertical ground water movement is expected to be a result of differences in subsurface material permeability and in the limited number of monitor wells (DOE, 1994). Adjacent to the Dolores River, static ground water elevations are approximately 10 to 15 ft (3 to 5 m) higher in the Navajo Sandstone wells (SRK-01-0669 and -0670) than in those screened in the alluvium (SRK-01-0505 to -0510). These static water levels are indicative of an upward vertical gradient (confined conditions) in the Navajo Sandstone near the Dolores River. The average linear horizontal ground water velocity of the Navajo Sandstone (0.58 ft/yr [$5.6 \times 10^{-7} \text{ cm/s}$]) is considerably lower than that of the Dolores River alluvium. Linear ground water velocity was calculated using an average hydraulic conductivity value of $2.4 \times 10^{-2} \text{ ft per day}$ ($8.5 \times 10^{-6} \text{ cm/s}$), a hydraulic gradient of 0.02, and an estimated effective porosity of 0.30 (DOE, 1994). The Navajo Sandstone is expected to be recharged by seepage from the overlying stratigraphic units when ground water movement is semiconfined. Ground water discharges into surrounding stratigraphic units.

2.1.4 Water quality

Water quality sampling has been conducted at the designated Slick Rock NC and UC processing sites since 1986. Constituents listed in Table 2.2 were analyzed during the initial screening monitoring to determine background and baseline ground water quality. This list was modified during subsequent sampling events to focus on the following hazardous constituents known to be related to uranium processing activities at the NC or UC processing sites: ammonium, barium, boron, cadmium, chromium, gross alpha, iron, lead-210, manganese, molybdenum, nitrate, polonium-210, radium-226, radium-228, selenium, silica, strontium, sulfate, thorium-230, uranium, vanadium, and zinc. Additional constituents also were analyzed for geochemical characterization: calcium,

FIGURE 2.4
WATER TABLE CONTOUR MAP FOR THE ENTRADA FORMATION WELLS,
UC PROCESSING SITE, SLICK ROCK, COLORADO

FIGURE 2.5
WATER TABLE CONTOUR MAP FOR THE NAVAJO SANDSTONE WELLS,
NC AND UC PROCESSING SITES, SLICK ROCK, COLORADO

Table 2.2 Analytical constituents measured for baseline water quality screening

Constituent	MCL ^a	Constituents without MCLs	
Arsenic	0.05	Aluminum	Magnesium ^{b,c}
Barium ^b	1.0	Ammonium ^b	Manganese ^b
Cadmium ^b	0.01	Antimony	Nickel
Chromium ^b	0.05	Beryllium	Phosphate
Lead	0.05	Boron ^b	Potassium ^c
Mercury	0.002	Bromide	Silica ^b
Molybdenum ^b	0.1	Calcium ^{b,c}	Sodium ^{b,c}
Nitrate ^{b,c}	44.0	Chloride ^{b,c}	Strontium ^b
Selenium ^b	0.01	Cobalt	Sulfate ^{b,c}
Silver	0.05	Copper	Sulfide
Combined radium ^b -226 and radium-228	5.0 ^d	Cyanide	Thallium
Combined uranium ^b -234 and -238	30.0 ^d	Fluoride	Tin
Net gross alpha ^b (excluding radon and uranium)	15.0 ^d	Iron ^b	Vanadium ^b
		Gross alpha ^b	Zinc ^b
		Total Kjeldahl nitrogen	Total organic carbon ^c / Dissolved organic carbon ^c
		Total dissolved solids ^c	Lead-210 ^b
		Polonium-210 ^b	Thorium-230 ^b

^aMaximum concentration limits (MCL) expressed in milligrams per liter unless otherwise noted.

^bPotential hazardous constituent related to uranium processing activities.

^cGeochemical characterization.

^dPicocuries per liter (pCi/L).

chloride, dissolved organic carbon, dissolved oxygen, magnesium, pH, nitrate, oxidation-reduction potential (ORP), potassium, sodium, specific conductance, sulfate, temperature, total dissolved solids (TDS), and total organic carbon.

In the *Technical Approach Document* (DOE, 1989) for the UMTRA Project surface remediation program, background ground water quality is defined as the quality of ground water that would be expected at the site if uranium processing had not occurred. Site characterization activities conducted to date at the Slick Rock processing sites were intended to provide sufficient preliminary site characterization information to design and implement a surface remediation plan (for relocating the RRM to the proposed Burro Canyon disposal site). Background water quality will need to be further characterized during the ground water compliance program (Subpart B of the UMTRA Project). However, for the purpose and scope of the surface remedial action phase of the UMTRA project, background ground water quality has been characterized as follows for each of the three hydrostratigraphic units (DOE, 1994):

- **Dolores River alluvium.** Background ground water quality in the alluvial materials is characterized as a calcium sodium sulfate type at both the NC and UC sites. Background ground water concentrations of TDS range from 622 to 991 milligrams per liter (mg/L) at the NC site and from 875 to 1180 mg/L at the UC site. The background pH ranges from 6.9 to 7.7; pH values are comparable at both the NC and UC sites. Concentrations or activities of chromium, molybdenum, uranium, and radium-226 plus radium-228 have exceeded the MCL in one or more background alluvial monitor wells on one or more occasions since 1986.
- **Entrada Formation.** Background ground water quality of the Entrada Formation is characterized as a calcium bicarbonate to sodium bicarbonate type. The pH of ground water in the Entrada Formation is slightly above neutral, ranging from 7.8 to 8.0. TDS concentrations measured in the Entrada Formation background monitor wells range from 147 mg/L to 1990 mg/L. Selenium and radium-226 plus radium-228 have exceeded their respective MCLs in ground water samples collected from the background monitor wells screened in the Entrada Formation on one or more occasions since 1986.
- **Navajo Sandstone.** From the current level of remedial action site characterization activities, it appears that ground water in the Navajo Sandstone has not been impacted by the former milling activities at either the NC or UC processing sites. Background ground water quality in the Navajo Sandstone is characterized as a sodium bicarbonate type at the NC site and as a magnesium bicarbonate type at the UC site. The pH of ground water measured in background NC and UC monitor wells screened in the Navajo Sandstone ranges from 7.2 to 7.8. TDS concentrations are generally lower at the UC site (ranging from 229 to 1160 mg/L) than at the NC site (ranging from 492 to 1530 mg/L). The MCLs for chromium, molybdenum, nitrate, radium-226 plus radium-228, selenium, silver and uranium were equaled or exceeded on one or more occasions in Navajo Sandstone background monitor well samples (DOE, 1994). However, most

of these exceedances have since been flagged as suspect in a review of potential anomalies in the historical data base.

Baseline ground water quality is defined as the representative water quality in a monitor well influenced by uranium processing activities (DOE, 1989). On-site and downgradient baseline ground water quality has been compared to that of background ground water for each of the three hydrostratigraphic units for characterization during the surface remediation phase of the UMTRA Project (DOE, 1994):

- **Dolores River alluvium.** Average TDS concentrations in baseline alluvial ground water (ranging from 2356 mg/L at the NC site to 3198 mg/L at the UC site) are approximately three times those of background. A precursory assessment indicates that the following constituents have been identified as human health constituents of potential concern at the Slick Rock NC processing site: lead-210, polonium-210, radium-226 plus radium-228 sodium, sulfate, thorium-230, and uranium. The human health constituents of potential concern at the UC processing site include: cadmium, chloride, iron, lead-210, manganese, molybdenum, nitrate, polonium-210, radium-226 plus radium-228, selenium, sodium, sulfate, strontium, thorium-230, uranium, and vanadium. The potential affects to human health and the environment from these constituents will be evaluated and discussed in a site-specific baseline risk assessment scheduled for production later this year.

Uranium and sulfate are excellent tracers of the extent of contamination and plume geometry at the Slick Rock processing sites. Concentrations of these constituents exceeding background levels in alluvial ground water decrease rapidly with distance from the tailings piles (DOE, 1994). The geometry and movement of the uranium plumes (Figure 2.6) mirrors that of the sulfate plumes (Figure 2.7). These figures indicate that the respective concentrations of uranium and sulfate decrease to background levels less than 400 ft (120 m) downgradient of the UC tailings and appear to be decreasing downgradient of the NC tailings. Additional site characterization may be necessary in the ground water phase of the UMTRA Project to quantify the nature and extent of contamination downgradient of the designated UMTRA Project sites.

- **Entrada Formation.** The baseline water quality of the Entrada Formation also appears to be affected by uranium processing activities; the average TDS concentration (1034 mg/L) in baseline Entrada monitor wells is over three times that observed for background Entrada monitor wells (310 mg/L) (DOE, 1994). Baseline concentrations of nitrate and selenium routinely exceed the MCL and background values.
- **Navajo Sandstone.** Baseline water quality in the Navajo Sandstone does not appear to be affected by processing activities. TDS, pH, and the regulated constituents show minimal variation between background and baseline water quality.

FIGURE 2.6
URANIUM CONCENTRATIONS IN ALLUVIAL GROUND WATER,
NC AND UC PROCESSING SITES, SLICK ROCK, COLORADO

FIGURE 2.7
SULFATE CONCENTRATIONS IN ALLUVIAL GROUND WATER,
NC AND UC PROCESSING SITES, SLICK ROCK, COLORADO

2.2 DATA COLLECTION OBJECTIVES

Data collection objectives (DCO) identify the reasons for collecting data, which include regulatory requirements, compliance monitoring, site characterization, and risk assessment.

Data quality objectives (DQO) define the manner in which samples are collected, handled, and analyzed. DQOs define analytical support levels and standard procedures for water sampling, preservation, transport, and various other field procedures; ensure procedures follow established quality assurance (QA) and quality control (QC) protocols; and provide analytical data validation. The WSAP guidance document (DOE, 1993) and applicable SOPs (JEG, n.d.) outline the DQOs to be followed during data collection and evaluation activities.

2.2.1 Regulatory requirements

The regulatory requirements for ground water and surface water sampling at the Slick Rock processing site are specified in 40 CFR Part 192 (1994).

2.2.2 Compliance monitoring

The preliminary final RAP for the Slick Rock UMTRA Project sites (DOE, 1994) is currently being reviewed by the NRC and CDPHE. Ground water monitoring is anticipated during surface remedial action at the NC and UC processing sites. This WSAP is consistent with the preliminary final RAP.

2.2.3 Site characterization

Previous site characterization activities conducted during the surface remediation phase of the UMTRA Project have indicated that former uranium processing activities have affected the water quality of the Slick Rock NC and UC sites. Ground water monitoring at the processing sites will continue.

2.2.4 Risk assessment

A baseline risk assessment is being conducted this fiscal year to assess potential risks to human health and the environment related to uranium processing activities at the designated UMTRA Project NC and UC processing sites. This risk assessment is being conducted under a ground water program in conjunction with Subpart B of 40 CFR Part 192.

Water quality data were collected in February 1994 in preparation for the development of a baseline risk assessment of the ground water contamination near the former NC and UC processing sites. DCOs for baseline risk assessment sampling at the processing site are based on an evaluation of hazardous constituents present at the site, the concentrations of detected constituents, the rate of ground water movement, and the presence of potential receptors at the sites and downgradient from the sites. A general discussion of water quality and contaminants of potential concern at the Slick Rock processing sites is provided in Section 2.1.4.

In addition to ground water samples, surface water and sediment samples were also collected in 1994 for the site-specific baseline risk assessment. Future ground water, surface water, and sediment sampling efforts will be contingent on the findings of the baseline risk assessment.

2.3 WATER SAMPLING PLAN

Water quality sampling is conducted at the processing site to ensure protection of human health and the environment and to define the extent of contamination. Sampling locations, constituent selection, and sampling frequency are discussed in Sections 2.3.1 to 2.3.3. Interpretation and evaluation of analytical data are discussed in Sections 2.3.4 and 2.3.5. WSAP modifications and termination of monitoring are discussed in Section 2.3.6.

2.3.1 Sampling locations

Ground water was sampled at DOE monitor wells on the Slick Rock mill sites and at the private wells in the vicinity. A total of 25 DOE monitor wells were sampled at the locations shown in Figure 2.1. Table 2.3 provides the rationale for each recommended sampling location and the order of sample collection (based on historical information regarding lowest to highest concentrations of hazardous constituents) for the DOE monitor wells. Filtered and unfiltered samples were collected from DOE monitor wells for the baseline risk assessment. When only a limited quantity of water was available, sample collection bottles were prioritized (from highest priority to lowest) as follows: metals, anions, gross alpha, radium-226, radium-228, lead-210, thorium-230, polonium-210. This order attains the maximum number of analytes using the least quantity of water available during sample collection.

One collector system for livestock and two nearby private wells were sampled. Table 2.4 provides a description and rationale for sampling private wells. Unfiltered private well samples were collected from a drinking water outlet downstream from any private filtering systems. Filtered and unfiltered samples were collected from the collector system.

A total of four surface water samples were collected along the Dolores River at the Slick Rock sites. Filtered and unfiltered surface water samples and a sediment sample were collected upgradient and downgradient of the NC and UC processing sites at the approximate locations shown in Figure 2.1. Table 2.5 provides a description and rationale for surface water sampling.

2.3.2 Constituent selection

The ground water monitoring program includes collecting and analyzing ground water samples from the wells listed in Tables 2.3 and 2.4 and discussed in Section 2.3.1. Ground water samples initially were evaluated for hazardous constituents generally expected to be in or derived from the RRM related to the uranium processing activities. Constituents analyzed during the screening monitoring to determine background and baseline ground water quality included

Table 2.3 DOE monitor well sampling locations for the NC and UC Slick Rock UMTRA Project processing sites and vicinity

Site	Well ID	Location	Formation of Completion ^a	Screened Interval (ft bls ^b)	Sampling rationale
UC	^c SRK-01-0505	Background	Alluvium	11.0 - 19.0	Characterize background ground water quality before tailings removal.
NC	^d SRK-01-0501	Background	Alluvium	12.0 - 21.0	
NC	SRK-01-0686	Background	Alluvium	15.0 - 20.0	
UC	SRK-01-0551	Background	Entrada	46.0 - 56.0	
UC	SRK-01-0703	Background	Entrada	41.8 - 51.8	Downgradient and beyond the current extent of contamination, these wells are used to detect the leading edge of the contaminant plume. Some locations may be eliminated from future WSAPs following completion of the baseline risk assessment.
UC	SRK-01-0552	Background	Navajo	68.0 - 78.0	
UC	SRK-01-0558	Background	Navajo	68.0 - 78.0	
UC	SRK-01-0668	Background	Navajo	111.0 - 151.0	
NC	SRK-01-0687	Background	Navajo	173.0 - 193.0	
UC	^e SRK-01-0684	Downgradient	Alluvium	11.0 - 21.0	
UC	^e SRK-01-0685	Downgradient	Alluvium	15.0 - 25.0	

Table 2.3 DOE monitor well sampling locations for the NC and UC Slick Rock UMTRA Project processing sites and vicinity (Continued)

Site	Well ID	Location	Formation of Completion ^a	Screened interval (ft bls ^b)	Sampling rationale
UC	^d SRK-01-0506	Onsite	Alluvium	12.0 - 19.0	Onsite and downgradient monitor wells within the plume are used to track plume migration. These wells provide data quality control through discrete interval sampling, lithologic log data, and a historical water quality data base. Some locations may be eliminated from future WSAPs following completion of the baseline risk assessment.
UC	^d SRK-01-0507	Onsite	Alluvium	10.0 - 20.0	
UC	^d SRK-01-0508	Onsite	Alluvium	12.0 - 19.0	
UC	^d SRK-01-0509	Onsite	Alluvium	12.0 - 22.0	
UC	^d SRK-01-0510	Onsite	Alluvium	15.0 - 24.0	
NC	^d SRK-01-0503	Onsite	Alluvium	20.0 - 26.0	
NC	^c SRK-01-0504	Onsite	Alluvium	14.0 - 18.0	
NC	SRK-01-0512	Onsite	Alluvium	12.0 - 20.0	
UC	SRK-01-0554	Onsite	Entrada	37.5 - 47.5	
UC	SRK-01-0702	Onsite	Entrada	55.0 - 65.0	
UC	SRK-01-0704	Onsite	Entrada	46.0 - 56.0	
UC	SRK-01-0669	Onsite	Navajo	100.0 - 105.0	
UC	SRK-01-0670	Onsite	Navajo	84.0 - 94.0	
UC	SRK-01-0688	Downgradient	Navajo	53.0 - 68.0	

^aHydrogeologic formation screened.^bBelow land surface.^cField measurements of NO₂/NO₃, Fe²⁺/Fe³⁺ and S/SO₄ taken at these locations.^dField measurements of NO₂/NO₃, Fe²⁺/Fe³⁺ taken at these locations.^eField measurements of Fe²⁺/Fe³⁺ taken at these locations.

Note: Order of collection is prioritized from cleanest samples to most contaminated.

Table 2.4 Private well sampling locations downgradient from the Slick Rock processing sites

Well ID	Description	Formation of Completion	Sampling rationale
SRK-01-0672	Domestic well	Unknown	Ensure protection of human health.
SRK-01-0805	Domestic well	Unknown	Monitored during baseline risk assessment analyses at a minimum.
SRK-01-0807	Collector system	Entrada	Ensures continued safety for livestock.

Table 2.5 Surface water sampling locations in the vicinity of the Slick Rock processing sites

Surface water location ID	Description	Sampling rationale
SRK-01-0696	Dolores River sample collected upgradient of NC site.	Determine background surface water quality of the Dolores River.
SRK-01-0693	Dolores River sample collected upgradient of UC site.	
SRK-01-0692	Dolores River sample collected downgradient of NC site.	Determine if former UMTRA Project uranium processing activities have affected the baseline surface water quality of the Dolores River downgradient of the tailings.
SRK-01-0694	Dolores River sample collected downgradient of UC site.	

those listed in Table 2.2 and discussed in Section 2.1.4. The list of constituents was modified during subsequent sampling events to reflect hazardous constituents suspected to be related to the uranium processing activities at these sites.

Based on existing water quality data, site characterization analyses, and determination of the data necessary for the baseline risk assessment, the

following constituents were monitored at NC and UC processing site monitor wells and private wells in 1994:

- Field parameters: alkalinity, dissolved oxygen, ORP, pH, specific conductivity, and temperature. In addition, nitrite/nitrate (NO_2/NO_3), ferrous/ferric iron ($\text{Fe}^{2+}/\text{Fe}^{3+}$), and sulfide/sulfate (S/SO_4) couples were measured in the field at the DOE monitor well clusters specified in Table 2.3.
- Laboratory analyses: ammonium, barium, boron, cadmium, calcium, chloride, chromium, dissolved organic carbon, gross alpha, iron, lead-210, magnesium, manganese, molybdenum, nitrate, polonium-210, potassium, radium-226, radium-228, selenium, silica, sodium, strontium, sulfate, TDS, thorium-230, total organic carbon, uranium, vanadium, and zinc.

Of these constituents, the following are being evaluated for inclusion in the baseline risk assessment as constituents of potential concern: ammonium, barium, boron, cadmium, calcium, chloride, chromium, gross alpha, iron, lead-210, magnesium, manganese, molybdenum, nitrate, polonium-210, potassium, radium-226 plus radium-228, selenium, silica, sodium, strontium, sulfate, thorium-230, uranium, vanadium, and zinc. A precursory list of selected constituents of potential concern is identified in Section 2.2.3. Constituents monitored for hydrogeochemical site characterization include calcium, chloride, dissolved organic carbon, magnesium, nitrate, potassium, sodium, sulfate, TDS, total organic carbon, and the field parameters. Based on the results of the baseline risk assessment, constituents of potential concern that are shown to have insignificant potential for risk at the sites may be eliminated from future WSAPs.

Filtered and unfiltered surface water samples collected from the Dolores River (Table 2.5) were analyzed for the following constituents:

- Field parameters: alkalinity, pH, specific conductivity, and temperature.
- Laboratory analyses: cadmium, calcium, dissolved organic carbon, magnesium, molybdenum, nitrate, selenium, total organic carbon, uranium, vanadium, and zinc.

Sediment samples were analyzed for cadmium, molybdenum, selenium, uranium, vanadium, and zinc.

2.3.3 Sampling frequency

Ground water has been monitored since 1986 to establish background and baseline ground water quantity at the Slick Rock processing sites prior to remedial action activities. Sampling to date allowed detection of seasonal variation in ground water quality. The sampling frequency permits evaluation of trends in ground water flow conditions and quality. It also provides additional information

and continuity to the data base which will be useful during the project's ground water compliance program.

The sampling schedule and the duration of the ground water monitoring program are determined by considering variations in historical background water quality measurements, the geochemistry of the source term (tailings pore fluid solution), the ground water flow rate, the possibility of seasonal variations in ground water quality, and the risk to human health and the environment.

Water quality sampling is being conducted annually prior to surface remedial action construction and is expected to be conducted at least annually during construction to monitor the effects of surface remedial action. Sampling frequency will then be determined using updated water quality and hydrologic data obtained during surface remedial action, results of the baseline risk assessment, and the ground water characterization program. Sampling frequency and the duration of ground water monitoring will be based on contaminant transport travel times and will account for a time lag after surface remedial action is complete. Based on the current hydrogeologic information available for the NC and UC processing sites, the linear ground water velocity in the Dolores River alluvium has been estimated to range from 100 ft/yr (0.97×10^{-4} cm/s) at the NC site to be 160 ft/yr (1.5×10^{-4} cm/s) at the UC site. The travel time estimate is expected to be refined further during the UMTRA Project ground water compliance program (Subpart B of 40 CFR Part 192).

2.3.4 Data Interpretation

Water sampling data will be analyzed and evaluated according to prescribed UMTRA Project procedures and then compared with the existing data base. Trends will be analyzed to detect variations in ground water flow conditions and ground water quality. Variations will be evaluated, and modifications to the sampling plan will be noted, justified, and implemented, as appropriate.

Long-term sampling frequency and parameters will be considered based on the following factors:

- Trends in concentrations over time - Was the elevation in concentration a one-time occurrence or part of a statistical trend?
- Spatial changes in concentrations of constituents of potential concern - Does the plume appear to be spreading horizontally or vertically? How does any apparent plume migration compare with the estimated contaminant transport travel times (based on current ground water flow velocity calculations)?
- Source term behavior - Does the mineralogy of subsurface soils, solubility of the hazardous constituents of concern, and ground water velocity suggest that source term concentrations are likely to increase or decrease with time?

Water quality and water level data are reviewed during the data validation process after each sampling and analysis event. These results are summarized in the UMTRA Project *Annual Site Environmental Report* (ASER). Notable trends and variations in water levels and water quality are included in this report. Seasonal fluctuations can be taken into account in trend evaluations. Conformance with, or deviations from, the conceptual model of the hydrogeological and geochemical environment at and in the vicinity of the Slick Rock NC and UC processing sites are also discussed and updated in the ASER, as well as in subsequent years' WSAPs, in RAP updates, and in the forthcoming baseline risk assessment for the Slick Rock processing sites.

2.3.5 Anomalous data evaluation

All water quality data will be subject to the rigorous data validation and QA/QC procedures outlined in UMTRA SOP 16.3.2 (JEG, n.d.). This procedure provides the criteria for the systematic evaluation of the results of radiochemical and general inorganic chemical analyses and documentation of the evaluation.

If water sampling results exceed the range of expected values, the suspect data will be further evaluated to determine the cause. Detailed procedures for evaluating anomalous data are also included in the WSAP guidance document (DOE, 1993).

2.3.6 Plan modifications and termination of monitoring

Water quality monitoring data will be reviewed annually and subsequent WSAPs will be updated and revised as necessary. Additional modifications may be needed after the source terms (tailings and RRM) are removed from the mill sites. Removal of the source terms will be a significant change to the aquifer baseline conditions.

If a notable increase is detected in contaminant concentration, several activities will be conducted to determine whether the increase indicates a significant change in water quality. Activities to determine the nature and extent of an increase in concentration may include reanalysis, resampling, comparison to other geochemical parameters, and trend analysis. Increases in analyte concentrations occur for various reasons, including 1) artifacts in the process of sample collection and laboratory analysis procedures, 2) changes in background water quality, 3) environmental changes unrelated to the uranium processing activities at the sites, and 4) a single localized pulse in the geochemical environment.

Ground water monitoring shall not continue after the ground water is determined to be in compliance with UMTRA Project ground water cleanup standards. Ground water monitoring shall then be terminated in consultation with CDPHE and NRC.

3.0 PROPOSED BURRO CANYON DISPOSAL SITE

3.1 SITE CONCEPTUAL MODEL

The site conceptual model is based on available hydrogeologic information, site reconnaissance, and data from monitor wells installed in the upper, middle, and lower sandstone units of the Burro Canyon Formation. Figure 3.1 shows monitor well locations in the vicinity of the proposed Burro Canyon disposal site. Table 3.1 provides monitor well construction information.

3.1.1 Physiographic setting

The proposed Burro Canyon disposal site is in the northeastern part of the Colorado Plateau physiographic province near the boundary it shares with the southern Rocky Mountain province. This portion of the Colorado Plateau is characterized by large-scale folds, unwarped plateaus, and deep narrow river canyons (DOE, 1994). The disposal site is located on the southeastern slope of a small mesa where on-site elevations range from approximately 5870 to 5910 ft (1790 to 1800 m) above MSL. The land surface drops to a relatively low elevation along the synclinal Disappointment Valley southeast of the site. The land surface to the west of the site area is deeply incised by the Dolores River and by tributary canyons.

3.1.2 Geology

The proposed Burro Canyon disposal site is located on a weathered pediment of Dakota Sandstone overlying the interbedded mudstones, siltstones, and sandstones of the Burro Canyon Formation. The lowest unit of Dakota Sandstone consists primarily of low-permeability carbonaceous shale and mudstone. Two thin sandstone layers, ranging in thickness from 1 to 6 ft (0.3 to 2 m), are interbedded with the shales and mudstones. The Dakota Sandstone is unsaturated in the site vicinity. Three water-bearing sandstone units of the Burro Canyon Formation underlie the Dakota Sandstone. The tops of these sandstone units generally are at approximate depths of 100, 200, and 300 ft (30, 60, and 90 m), and are described as the upper, middle, and lower units, respectively. They are fine- to medium-grained sandstone layers ranging from 25 to 75 ft (7.6 to 23 m) in thickness and are hydrogeologically separated from one another by thick interbedded claystone, mudstone, and siltstone sequences (hereafter referred to as mudstone). A geologic cross section is provided in Figure 3.2.

3.1.3 Hydrology

The first saturated hydrogeologic unit (uppermost aquifer) is the upper sandstone unit of the Burro Canyon Formation. Ground water in the upper sandstone unit of the Burro Canyon Formation is semiconfined and the yield is very low. The top of the upper sandstone unit is 50 to 100 ft (20 to 30 m) below the surface. The depth to the water table ranges from 75 to 110 ft (23 to 34 m). Measured ground water elevations have remained constant over

Table 3.1 DOE monitor well information for the proposed Burro Canyon disposal site, Slick Rock, Colorado

SITE: SRK02 BORROW SITE 1 (BURRO CANYON)
REPORT DATE: 06/30/94

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT)	BOREHOLE DIAMETER (INCHES)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT)	CASING DIAMETER (INCHES)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0517	19217.00	22547.00	5870.2	340.	6.13	5871.80	340.	2.	328.	10.	0	LB
0519	19960.00	21758.00	5897.1	338.	8.	5898.12	338.	4.	316.	20.	0	LB
0521	19621.00	22459.00	5875.0	353.	8.	5876.05	352.	4.	330	20	0	LB
0524	19012.06	21702.85	5848.9	295.5	8.	5850.72	295.5	4.	273.5	20.	0	LB
0516	19099.00	21931.00	5862.4	225.	6.13	5864.36	225.	2.	213.	10.	0	MB
0520	19974.00	21748.00	5897.8	240.5	8.	5899.49	240.5	4.	218.5	20.	0	MB
0522	19670.00	22470.00	5874.6	235.	8.	5876.50	235.	4.	203.	30.	0	MB
0525	19023.44	21712.23	5849.1	203.	8.	5850.89	203.	4.	171.	30.	0	MB
0526	18859.00	22153.00	5833.8	207.	8.	5835.42	207.	4.	175.	30.	0	MB
0528	20137.00	22121.00	5896.8	223.	8.	5898.37	223.	4.	201.	20.	0	MB
0518	19959.00	21745.00	5897.0	109.	8.	5898.03	109.	4.	97.	10	0	UB
0523	19620.00	22476.00	5875.0	125.	8.	5876.39	125.	4.	103.	20.	0	UB
0527	18873.00	22141.00	5834.6	81.	8.	5836.51	81.	4.	59.	20.	0	UB
0529	20126.00	22114.00	5896.6	119.	8.	5898.51	119.	4.	107.	10.	0	UB
0551	18590	22770	5823.0	112	5.875	5824.5	112	2	90	20	0	UB
0552	18920	22830	5843	179	7.25	5844.5	100.5	2	78.15	20	0	UB

FORMATION OF COMPLETION CODE:

LB - LOWER BURRO CANYON

MB - MIDDLE BURRO CANYON

UB - UPPER BURRO CANYON

FLOW RELATIONSHIP CODE:

0 - ON-SITE

DATA FILE: M:\DART\SRK02\MMI10003.DAT

FIGURE 3.2
GEOLOGIC CROSS SECTION (NORTHWEST-SOUTHEAST)
OF THE BURRO CANYON DISPOSAL SITE, SLICK ROCK, COLORADO

time. The average linear ground water velocity in the upper sandstone unit has been estimated at 6 ft/yr (6×10^{-6} cm/s), based on an average hydraulic conductivity of 4×10^{-2} ft per day (1×10^{-5} cm/s), a hydraulic gradient of 0.04, and an effective porosity of 0.1. Ground water flow is to the southeast (Figure 3.3). The upper sandstone unit (uppermost aquifer) is not a current or potential source of drinking water because the quantity of water available is less than 150 gallons per day (gpd) (6.6×10^{-3} liters per second [L/s]), as evidenced by on-site aquifer performance tests. As a result, the ground water in the upper sandstone unit is Class III (limited use) ground water, as defined in 40 CFR 192.11(e) of the EPA-proposed ground water standards (DOE, 1994).

The Burro Canyon middle sandstone unit is a confined aquifer approximately 50 ft (15 m) thick. It is overlain by approximately 60 to 70 ft (about 18 to 21 m) of laterally extensive mudstone. The top of the middle sandstone unit occurs between 140 and 190 ft (43 to 58 m) below the surface in the vicinity of the disposal cell footprint. The potentiometric surface is approximately 40 ft (12 m) above the top of the middle sandstone unit, resulting in an upward hydraulic gradient. The average linear ground water velocity of the middle sandstone unit is 2 ft/yr (2×10^{-6} cm/s), assuming an average hydraulic conductivity of 9×10^{-2} ft per day (3×10^{-5} cm/s), a hydraulic gradient of 0.02, and an effective porosity of 0.2. The direction of ground water flow is to the southeast.

The Burro Canyon lower sandstone unit is approximately 39 ft (12 m) thick beneath the disposal cell, and the top of the unit is located approximately 250 to 300 ft (76 to 91 m) below the ground surface. Ground water in this unit is confined by the thick sequence of overlying low-permeability mudstones and siltstones of the Burro Canyon Formation and has an upward gradient with the potentiometric surface averaging 52 ft (16 m) above the middle sandstone unit. The average linear ground water velocity in the lower sandstone unit is 1 ft/yr (1×10^{-6} cm/s), assuming a hydraulic conductivity of 5×10^{-3} ft per day (2×10^{-6} cm/s), a gradient of 0.06, and an effective porosity of 0.1. The lower sandstone unit has an extremely low velocity and well yield. Vertical recharge to and discharge from the lower sandstone unit is restricted because the low-permeability interbedded claystone and siltstone strata impede infiltration.

The source of recharge is approximately 0.25 to 0.75 mi (0.40 to 1.2 km) northeast of the site. Sandstone beds outcrop along the east limb of the Disappointment syncline and intercept tributaries to the Nicholas Wash drainage system. Ground water then flows to the southeast and eventually discharges into the surrounding geologic strata south of the Burro Canyon disposal site.

3.1.4 Water quality

Water quality sampling has been conducted at the proposed Burro Canyon disposal site since 1990. Constituents analyzed during the screening monitoring to determine background ground water quality included those listed in Section 2.1.4. This list was modified during subsequent sampling events to focus on hazardous constituents related to uranium processing activities at the Slick Rock processing sites and was compared to background concentrations at the proposed Burro Canyon disposal site.

Background ground water quality in each hydrostratigraphic unit within the Burro Canyon Formation was determined from analyses of ground water from monitor wells completed in each unit. Ground water quality data was characterized individually for each hydrostratigraphic unit because the units are hydrogeologically separated (DOE, 1994). In general, ground water pH is near neutral, and TDS concentrations tend to decrease with depth. Background ground water quality is characterized as follows for each of the three hydrostratigraphic units:

- **Burro Canyon upper sandstone unit.** Ground waters in this unit are sodium sulfate and sodium bicarbonate types. TDS concentrations range from 556 to 973 mg/L. Ground water is neutral to alkaline with pH ranging from 7.5 to 9.1. On one occasion, the activity of radium-226 plus radium-228 has equaled or slightly exceeded its MCL in samples collected from monitor wells SRK-02-0518 and -0529. In addition, the naturally occurring concentration of selenium consistently exceeds the MCLs in ground water samples collected from monitor well SRK-02-0518.
- **Burro Canyon middle sandstone unit.** Monitor wells screened in the middle sandstone unit produce ground waters that are characterized as sodium bicarbonate and sodium sulfate types; the pH ranges from 7.2 to 7.6. TDS concentrations range from 422 mg/L to 696 mg/L. On one occasion, the activity of radium-226 plus radium-228 slightly exceeded its MCL in one monitor well (SRK-02-0516).
- **Burro Canyon lower sandstone unit.** Samples collected from the lower sandstone unit monitor wells contain sodium bicarbonate ground water. TDS concentrations range from 256 mg/L to 485 mg/L. The ground water of the lower sandstone unit is relatively alkaline, with pH ranging from 8.6 to 9.6. All water quality samples collected from monitor wells screened in the lower unit have been below the MCLs for all regulated constituents.

3.2 DATA COLLECTION OBJECTIVES

DCOs identify the reasons for collecting data, including regulatory requirements, compliance monitoring, site characterization, risk assessment, and other considerations. DQOs define the manner in which samples are collected, handled, and analyzed; define analytical support levels; follow standard procedures for water sampling, preservation, and transport and for various other field activities; ensure that sampling and analysis procedures follow QA and QC protocols; and provide analytical data validation. DQOs for data collection and evaluation activities are stated in the WSAP guidance document (DOE, 1993) and applicable SOPs (JEG, n.d.).

3.2.1 Regulatory requirements

No regulatory requirements for ground water monitoring apply to the proposed Burro Canyon disposal site. DCOs are related to site characterization (Section 3.2.3).

3.2.2 Compliance monitoring

To comply with proposed EPA ground water protection standards (Subpart A of 40 CFR Part 192), the DOE has proposed to apply supplemental standards for limited use of ground water resulting from low yield (less than 150 gpd [6.6×10^{-3} L/s]) in the uppermost aquifer, as discussed in the preliminary final RAP (DOE, 1994). Ground water in lithologic units underlying the upper sandstone unit of the Burro Canyon Formation (uppermost aquifer) is protected from potential site-related contamination by hydrogeologic isolation. Low permeability mudstone units separate the upper, middle, and lower sandstone units of the Burro Canyon Formation, and upward vertical hydraulic gradients in the lower and middle sandstone units inhibit the downward migration of water. As a result, the proposed remedial action will ensure protection of human health and the environment. Furthermore, the DOE has determined that proposing ground water concentration limits and monitoring at a point of compliance at the proposed Burro Canyon disposal site would not further protect human health and the environment. Additional information is provided in the preliminary final RAP (DOE, 1994) and will be described in the future in a site-specific Slick Rock long-term surveillance plan (LTSP). Compliance monitoring in upcoming years is contingent on regulatory agency concurrence on the preliminary final RAP.

3.2.3 Site characterization

Water sampling activities conducted prior to and during 1994 have provided detailed characterization of background water quality for the preliminary final RAP (DOE, 1994). The Technical Assistance Contractor has determined that additional water sampling for site characterization at the proposed disposal site is not necessary. The DOE agrees with this determination. However, water sampling at the proposed disposal site is currently a planned activity for the upcoming year, and will remain so until the DOE receives agency concurrence that site characterization of ground water quality is complete.

3.3 WATER SAMPLING PLAN

3.3.1 Sampling locations

Fourteen DOE monitor wells were sampled on one or more occasions from February to April 1994, to assess background conditions at the proposed Burro Canyon disposal site prior to surface remedial action. Water sampling at the disposal site had originally been scheduled for February. However, the sampling round was not completed and additional follow-up sampling was necessary to get a complete set of water quality data for a given seasonal time-frame. The DOE monitor well sampling locations are shown in Figure 3.1. Additional monitor well information is provided in Table 3.2. All ground water samples collected from the disposal site were filtered.

No surface water or private well sampling locations exist in the disposal site vicinity.

Table 3.2 DOE monitor well sampling locations for the proposed Burro Canyon disposal site, Slick Rock, Colorado

Well ID	Formation of Completion ^a	Screened interval (ft bls ^b)	Sampling rationale
SRK-02-0518	Upper	97.0 - 107.0	Detailed characterization of background water quality to define ground water changes after remedial action construction.
SRK-02-0523	Upper	103.0 - 123.0	
SRK-02-0527	Upper	59.0 - 79.0	
SRK-02-0529	Upper	107.0 - 117.0	
SRK-02-0516	Middle	213.0 - 223.0	Detailed characterization of background water quality to define ground water changes after remedial action construction.
SRK-02-0520	Middle	218.5 - 238.5	
SRK-02-0522	Middle	203.0 - 233.0	
SRK-02-0525	Middle	171.0 - 201.0	
SRK-02-0526	Middle	175.0 - 205.0	
SRK-02-0528	Middle	201.0 - 221.0	
SRK-02-0517	Lower	328.0 - 338.0	Detailed characterization of background water quality to define ground water changes after remedial action construction.
SRK-02-0519	Lower	316.0 - 336.0	
SRK-02-0521	Lower	330.0 - 350.0	
SRK-02-0524	Lower	273.5 - 293.5	

Notes:

^aSandstone unit of the Burro Canyon Formation.

^bBelow land surface.

3.3.2 Constituent selection

The ground water monitoring program includes collecting and analyzing ground water samples from the monitor wells listed in Section 3.3.1. Ground water samples initially were evaluated for the hazardous constituents that are generally expected in or derived from the RRM related to the uranium processing activities for comparative purposes after tailings disposal is complete.

Constituents analyzed during the screening monitoring to determine background ground water quality included those listed in Section 2.1.4 and Table 2.2. The list of constituents was modified during subsequent sampling events to reflect

hazardous constituents specifically related to uranium processing activities at the Slick Rock sites. Based on existing ground water quality data, the current list for the proposed Burro Canyon disposal site includes the following constituents:

- Field parameters: alkalinity, dissolved oxygen, ORP, pH, specific conductivity, and temperature.
- Laboratory analyses: barium, boron, cadmium, calcium, chloride, chromium, gross alpha, iron, magnesium, molybdenum, potassium, radium-226, radium-228, selenium, silica, sodium, strontium, sulfate, TDS, total organic carbon, uranium, vanadium, and zinc.

These constituents were chosen based on a comparison between potentially hazardous constituents detected in the tailings source term and the relative background concentrations measured at the proposed disposal site. Some of these analytes may be omitted from future WSAPs, based on further analysis and recommendations in the LTSP.

3.3.3 Sampling frequency

Ground water has been monitored at the proposed Burro Canyon disposal site since 1990 to establish background ground water quality before surface remedial action. Historical sampling has shown insignificant seasonal variation in ground water quality and elevations. Future ground water sampling activities are contingent on final resolution of the RAP.

3.3.4 Data interpretation

Water quality data collected during 1994 will be analyzed and evaluated according to prescribed UMTRA Project procedures and compared with the existing data base. Trends will be analyzed to detect any variations in ground water flow conditions and ground water quality. Variations will be evaluated and modifications to future WSAPs will be noted, justified, and implemented as appropriate.

3.3.5 Anomalous data evaluation

If water sampling results are beyond the range of expected values, the suspect data will be evaluated to determine the cause. If the deviation cannot be related to an error in sample collection, analysis, or to processes reasonably expected to occur in the hydrogeologic environment, the location will be resampled during the next scheduled sampling round. Detailed procedures for evaluating anomalous data are included in the WSAP guidance document (DOE, 1993).

3.3.6 Plan modifications and termination of monitoring

As discussed in Section 3.2.2 of this report and detailed in the preliminary final RAP (DOE, 1994), ground water compliance monitoring is not anticipated during or following surface remedial action construction. The final performance-monitoring strategy will be presented in a site-specific LTSP. Future modifications will be based on final resolution of the RAP and the findings of an approved LTSP for the Slick Rock disposal site.

4.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this document.

Name	Contribution
K. Monks	Overall document responsibility; authorship
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A. Groffman	Geochemistry
K. Monks	Hydrology, hydrogeology
J. Marshall	Risk assessment, toxicology
V. Beck	Editing
Creative Computer Services	Text processing
B. Harvey	Graphic design

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- 52 FR 36000, "EPA Standards for Remedial Actions at Inactive Uranium Processing Sites; Proposed Rule," September 24, 1987.

UNITED STATES CODE

42 USC §7901 *et seq.* Uranium Mill Tailings Radiation Control Act, November 8, 1978.

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