EPA 520/1-88-023
March 1989

GROUND-WATER PROTECTION STANDARDS FOR INACTIVE URANIUM TAILINGS SITES (40 CFR 192)

BACKGROUND INFORMATION FOR FINAL RULE

Office of Radiation Programs
Environmental Protection Agency
Washington, D.C. 20460

CONTENTS

List of Figures

List of Tables

List of Tables (continued)

List of Tables (continued)

Chapter 1

INTRODUCTION

In enacting the Uranium Mill Tailings Radiaton Control Act of 1978 (Public Law 95-604, 42 USC 7901), the Congress found that:

- "Uranium mill tailings located at active and inactive mill operations may pose a potential and significant radiation health hazard to the public, and that..."

- "Every reasonable effort should be made to provide for the stabilization, disposal, and control in a safe and environmentally sound manner of such tailings in order to prevent or minimize radon diffusion into the environment and to prevent or minimize other environmental hazards..."

To these ends, the Act required the Environmental Protection Agency (EPA) to set generally applicable standards to protect the public against both radiological and nonradiological hazards posed by residual radioactive materials at the 22 uranium mill tailings sites designated in the Act and at additional sites where these materials are deposited that may be designated by the Secretary of the Department of Energy (DOE). Residual radioactive material means (1) tailings waste resulting from the processing of ores for the extraction of uranium and other valuable constituents, and (2) other wastes, including unprocessed ores or low grade materials, as determined by the Secretary of Energy, at sites related to uranium ore processing. We will use the term tailings to refer to all of these wastes.

Standards were promulgated on January 5, 1983, however, they were challenged in the Tenth Circuit Court of Appeals by several industrial and environmental groups (Case Nos. 83-1014, 83-1041, 83-1206, and 83-1300). On September 3, 1985, the court dismissed all challenges except one: it set aside the ground-water provisions of the regulations at 40 CFR 192.20(a)(2)-(3) and remanded them to EPA "...to treat these toxic chemicals that pose a ground-water risk as it did in the active mill site regulations."

In the active mill site regulations (40 CFR 192 Subparts D and E), the EPA set general numerical standards to which the owners/operators of the active sites had to conform to receive a license from the Nuclear Regulatory Commission (NRC). For the Title I sites, EPA set qualitative standards for ground water protection that allowed the DOE and NRC to determine what actions were needed on a site-by-site basis. It was this standard that was rejected by the courts and has resulted in the rulemaking for which this is the Background Information Document (BID).

Standards were proposed on September 24, 1987 for ground water protection at the inactive uranium mill tailings sites (EPA 87a). Public hearings were held in Durango, Colorado on October 29, 1987. The public comment period was closed on January 29, 1988 (EPA 88). A draft Background Information Document was issued with the proposed standards (EPA 87b). Comments received during the public comment period have been considered and incorporated where applicable in the development of the final standards. A separate "Response to Comments" document (EPA 520/1-88-055) contains EPA's detailed responses to the comments received and is available upon request.

The purpose of this final BID is to summarize the information and data considered by the Agency in developing the ground-water protection standards. New information supplied by the Department of Energy has also been included. Information in the final environmental impact statements for previous rulemakings for uranium mill tailings (EPA82, EPA83) was also considered in this rulemaking. Further, the National Academy of Science report, "Scientific Basis for Risk Assessment and Management of Uranium Mill Tailings," (NAS86) was also considered by the Agency.

Chapter 2 of the BID presents a brief description of the Title II ground water standard and how it can be used to develop the Title I rulemaking. A description of the 24 designated uranium tailings sites and their current status in the DOE remedial action program is included in Chapter 3. Chapter 4 presents a detailed analysis of the available data on the ground water in the vicinity of 14 of the 24 sites.

Chapter 5 describes different methods that can be used for the restoration of ground water. DOE may use these methods or may use others that they consider more appropriate. The costs of using these restoration methods are discussed in Chapter 6. Lastly, Chapter 7 contains other considerations pertinent to the proposed standards.

REFERENCES

EPA82 ENVIRONMENTAL PROTECTION AGENCY, Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192), EPA 520/4-82-013-1 and 2, U.S. Environmental Protection Agency, 401 M St, SW, Washington, D.C. 20460 (October 1982)

EPA83 ENVIRONMENTAL PROTECTION AGENCY, Final Environmental Impact Statement for Standards for the Control of Byproduct Materials from Uranium Ore Processing (40 CFR 192), EPA 520/1-83-008-1 and 2, U.S. Environmental Protection Agency, 401 M St, SW, Washington, D.C. 20460 (September 1983)

EPA87a ENVIRONMENTAL PROTECTION AGENCY, Standards for Remedial Actions at Inactive Uranium Processing Sites; Proposed Rule, 52 FR 36000, Sept 24, 1987.

EPA87b ENVIRONMENTAL PROTECTION AGENCY, Ground Water Protection Standards for Inactive Uranium Tailings Sites - Background Information for Proposed Rule, EPA 520/1-87-014, July 1987.

EPA88 ENVIRONMENTAL PROTECTION AGENCY, Standards for Remedial Actions at Inactive Uranium Processing Sites, 53FR 1641, January 21, 1988.

NAS86 NATIONAL ACADEMY OF SCIENCE, NATIONAL RESEARCH COUNCIL, Scientific Basis for Risk Assessment and Management of Uranium Mill Tailings, National Academy Press, Washington, D.C. 20418 (1986)

Chapter 2

BACKGROUND

2.1 LEGISLATIVE HISTORY

The early history of uranium milling was discussed in Chapter 2 of the Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192), EPA 520/4-82-013-1, October 1982. In 1978 Congress passed Public Law 95-604, the Uranium Mill Tailings Radiation Control Act of 1978 (UMTRCA). UMTRCA was divided into two parts; Title I covering 22 inactive and abandoned sites and Title II covering those sites for which licenses had been issued by the Nuclear Regulatory Commission or its predecessor or by an Agreement State. Under this Act, the Environmental Protection Agency was charged with developing standards of general application to govern the remedial activities of the Secretary of Energy or his designee under section 275a. of the Atomic Energy Act of 1954 for those sites identified under Title I. The Department of Energy identified two additional sites to be included under the provisions of Title I, bringing the total number of sites under Title I to 24. The standards to be promulgated under Title I were required, to the maximum extent practicable, to be consistent with the requirements of the Solid Waste Disposal Act (SWDA) as amended. The SWDA includes the provisions of the Resource Conservation and Recovery Act (RCRA).

2.2 RULEMAKING HISTORY

On June 11, 1979, a Federal Register Notice requesting information and data relevant to the development of the standards and of a report to Congress on uranium mining wastes. Because UMTRCA required EPA to promulgate standards before DOE could begin cleanup of tailings and because some buildings had been found to be contaminated with tailings resulting in radiation levels which were highly dangerous to anyone exposed to them for a long time, interim standards for cleanup of residual radioactivity that had contaminated land and buildings were published in the Federal Register on April 22, 1980. This allowed DOE to proceed with the cleanup of offsite tailings contamination without waiting for the formal promulgation of a regulation through the EPA rulemaking process. At the same time, proposed standards for the cleanup of the inactive mill tailings were published for comment.

The proposed cleanup standards were followed by proposed disposal standards that were published in the Federal Register on January 9, 1981. The disposal standards applied to the tailings at the 24 designated sites and were designed to place them in a condition which will be safe for a long time. Final standards for the disposal and cleanup of inactive uranium mill tailings were issued on January 5, 1983. The American Mining Congress and others immediately petitioned the Tenth Circuit Court of Appeals for a review of the standards.

On September 3, 1985, the Tenth Circuit Court of Appeals upheld the inactive mill tailings standards except for the ground-water protection portions located at 40 CFR 192.20(a)(2) and (3) which were remanded to EPA for revision. EPA had promulgated qualitative standards for ground water protection and the Court found that quantitative standards similar to those promulgated for the sites that were regulated under UMTRCA Title II were necessary. The Court did not set a time limit on establishing the new standards. On June 2, 1986, the U.S. Supreme Court declined to review all appeals of decisions on this case. As noted in Chapter 1, the Agency proposed ground water standards on September 24, 1987.

2.3 INFORMATION CONSIDERED IN DEVELOPING THE STANDARDS

In 1986, Congress passed the Superfund Amendments and Reauthorization Act which amended the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. In the discussion of this bill, Congress established the concept that the Administrator be allowed to use alternate technologies where applicable standards set under other environmental laws are based on specific technologies. The RCRA amendments to SWDA provided only minimal direction from Congress for the cleanup of old contamination that existed before RCRA was promulgated. Therefore, EPA is using part of the SARA philosophy in the the cleanup portions of the Title I standards by incorporating some of the provisions from SARA into the Title I ground-water standards. These provisions are an exemption if it can be shown that the cleanup of contaminated ground water is technically impracticable from an engineering perspective and an exemption if it can be shown that cleanup of the contaminated ground water would cause more environmental harm than it would prevent if the water were not cleaned up.

The Office of Ground Water Protection in EPA has developed draft guidelines for classifying ground water based on its use or potential use as a source of drinking water. EPA is allowing the use of alternate standards for Class III ground water as defined by the ground water classification system established in EPA's 1984 Ground Water Protection Strategy.

Procedures for classifying ground water are presented in "Guidelines for Ground-Water Classification under the EPA Ground-Water Protection Strategy" released in final draft in December 1986 and due to be finalized during the fall of 1988. Under these draft guidelines, Class I ground waters would encompass resources of particularly high value or that are highly vulnerable; e.g. an irreplaceable source of drinking water or ecologically vital ground water. Class II ground waters would include all non-Class I ground water that is currently used or is potentially adequate for drinking water or other beneficial use. Class III would encompass ground waters that are not a current or potential source of drinking water due to widespread, ambient contamination caused by natural or human-induced conditions or inadequate capacity to provide sufficient quantities of water to meet the needs of an average household. Human-induced conditions would specifically exclude the contribution from the uranium mill tailings being regulated. At sites with Class III ground water, the proposed supplemental standards would require only such management of contamination due to tailings as would be required to prevent any additional adverse impacts on human health and the environment from that contamination.

2.4 REFERENCES

EPA79 ENVIRONMENTAL PROTECTION AGENCY, Development of Standards for Uranium Mill Tailings and Report on Uranium Mining Wastes; Call for Information and Data, U.S. Environmental Protection Agency, Washington, D.C. 20460, Federal Register, V. 44, No. 113, p. 33433 (June 11, 1979)

EPA80a ENVIRONMENTAL PROTECTION AGENCY, Interim Cleanup Standards for Inactive Uranium Processing Sites, U.S. Environmental Protection Agency, Washington, D.C. 20460, Federal Register, V. 45, No. 79, pp. 27366-8 (April 22, 1980)

EPA80b ENVIRONMENTAL PROTECTION AGENCY, Proposed Cleanup Standards for Inactive Uranium Processing Sites; Invitation for Comment, U.S. Environmental Protection Agency, Washington, D.C. 20460, Federal Register, V. 45, No. 79, pp. 27370-5 (April 22, 1980)

EPA81 ENVIRONMENTAL PROTECTION AGENCY, Proposed Disposal Standards for Inactive Uranium Processing Sites; Invitation for Comment, U.S. Environmental Protection Agency, Washington, D.C. 20460, Federal Register, V. 46, No. 6, pp. 2556-63 (January 9, 1981)

EPA82 ENVIRONMENTAL PROTECTION AGENCY, Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192), EPA 520/4-82-013-1, U.S. Environmental Protection Agency, 401 M St, SW, Washington, D.C. 20460 (October 1982)

EPA83 ENVIRONMENTAL PROTECTION AGENCY, Standards for Remedial Actions at Inactive Uranium Processing Sites, U.S. Environmental Protection Agency, Washington, D.C. 20460, Federal Register, V. 48, No. 3, pp. 590-606 (January 5, 1983)

CHAPTER 3

SITE DESCRIPTIONS AND STATUS

There are 24 processing sites (Fig. 3-1) designated under Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA). All but one of these sites are located in the generally semi-arid to arid western United States. Detailed site descriptions have been presented in Engineering Assessment Reports prepared on each site for the Department of Energy by Ford, Bacon & Davis Utah Inc. These have been supplemented by more specific site investigations, remedial action plans, environmental analyses and detailed ground water quality investigations as necessary.

The sites vary in location from isolated sparsely-populated rural settings to populated urban communities. Demographic information for each site is presented in Table 3-1.

The sites typically are in areas of alluvium underlain by poorly to moderately consolidated sedimentary formations. Ground water tends to be scarce and of poor quality. Pertinent summary information regarding the topography, geology, hydrology, and soil characteristics of each site is presented in Table 3-2.

The majority of the sites occur in the semi-arid to arid western United States, in areas characterized by infrequent but often very intense rainstorms. In the northern areas, much of the annual precipitation may occur in the winter months as snowfall. Site-specific precipitation and wind records for many of the sites are lacking because of the remote locations. Meteorological information from the nearest comparable localities are summarized for each site in Table 3-3.

The tailings contain residual radioactive materials, including traces of unrecovered uranium and most of the daughter products, as well as various heavy metals and other elements often at levels exceeding established standards. The quantity of tailings, contained radioactivity, and proposed remedial action are summarized for each site in Table 3-4. The concentrations of specific elements which could present public health risks through ground water contamination are given in Table 3-5.

All of the sites investigated show at least local contamination of groundwater by surface waters and precipitation leaching through the tailings materials. Areal extent of contamination ranges from the immediate vicinity of the site to as far as 1/2 mi down-gradient. Available groundwater contamination data are summarized in Table 3-6.

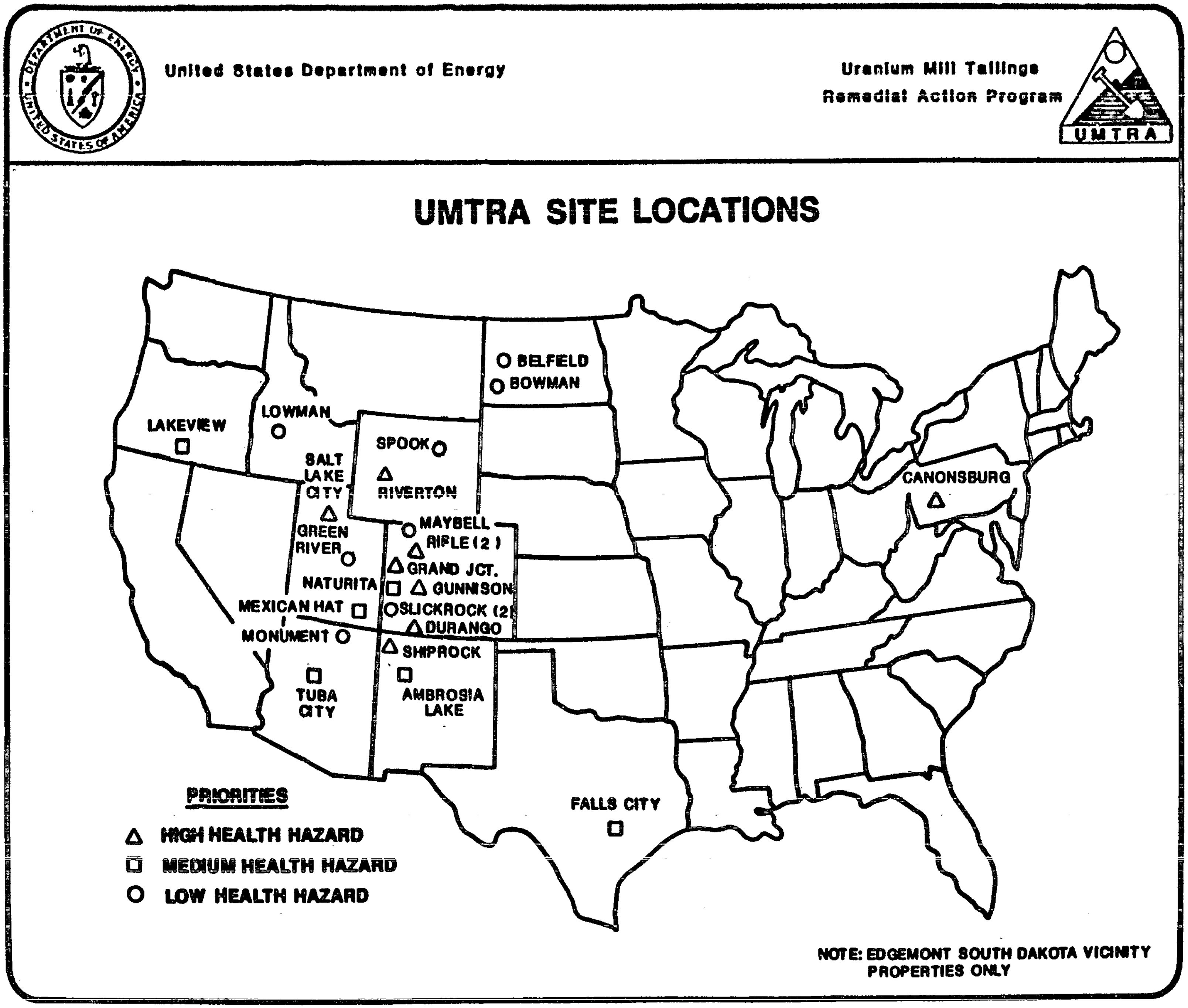


Figure 3-1. LOCATION - UMTRA PROJECT SITES

Table 3-1. DEMOGRAPHICS OF INACTIVE URANIUM MILL TAILINGS SITES

SITE NAME	COUNTY NAME	POPULATION 0-1km	0-3km	0-5km	NEAREST COMMUNITY NAME	DISTANCE	LOCAL LAND USE	WATER USES IN AREA
Monument Valley, AZ	Navajo	20	44	60	Monument Valley	---	rural grazing, IR*	2 alluvial well and seeps, domestic & livestock
Tuba City, AZ	Coconino	18	45	64	Tuba City	5.5mi	rural grazing, IR*	2 sources within 2 mi
Durango, CO	La Plata	1221	7260	12058	Durango	---	urban, industrial	none within 2 mi
Grand Junction, CO	Mesa	843	16634	38011	Grand Junction	---	urban, industrial	local sources from deeper aquifers
Gunnison, CO	Gunnison	396	6523	7315	Gunnison	---	urban	numerous shallow domestic wells within 1 mi of site
Maybell, CO	Moffat	0	0	0	Craig	25mi	rural grazing	domestic water wells 4-6 mi from site
Naturita (RE), CO	Montrose	3	3	3	Naturita	2mi	rural grazing	3 alluvial wells upgradient, river water downstream used for irrigation, 1 deep well within 2 mi
New Rifle, CO	Garfield	96	693	723	Rifle	---	urban, agricultural	47 wells within 2 mi, 1 used by South Rifle for domestic water, Colorado River major source of domestic water
Old Rifle, CO	Garfield	1471	5251	5659	Rifle	---	urban, agricultural	
Slick Rock (NC), CO	San Miguel	5	10	10	Slick Rock	3mi	rural, grazing	local needs supplied by deep bedrock aquifers
Slick Rock (UC), CO	San Miguel	39	39	39	Slick Rock	3mi	rural, grazing	
Lowman, ID	Boise	85	172	218	Lowman	---	rural, grazing	shallow wells and surface water usage
Ambrosia Lake, NM	McKinley	0	2	2	Grants	25mi	rural, grazing	none known
Shiprock, NM	San Juan	155	3093	4948	Shiprock	---	urban, mixed, IR*	local use of groundwater from floodplain
Belfield, ND	Stark	65	1428	1584	Belfield	0.5mi	urban, industrial	scattered domestic and stock use
Bowman, ND	Bowman	3	15	33	Bowman	7mi	rural, agricultural	domestic and stock use
Lakeview, OR	Lake	16	2263	4184	Lakeview	---	urban, industrial	domestic, irrigation and municipal wells 100' or more
Canonsburg, PA	Washington	3910	17024	22135	Canonsburg	---	urban, industrial	none known
Falls City, TX	Karnes	3	21	45	Falls City	10mi	rural, grazing	4 livestock wells within 2 mi
Green River, UT	Grand	14	1081	1498	Green River	1mi	urban, mixed	no groundwater usage near site; Green River fm tapped
Mexican Hat, UT	San Juan	4	384	384	Mexican Hat	1.5mi	rural, grazing, IR*	none known
Salt Lake City, UT	Salt Lake	203	18468	91498	Salt Lake City	---	urban, industrial	shallow water not used, numerous domestic wells
Converse Co., WY	Converse	0	9	18	Glenrock	32mi	rural, grazing	few local wells, domestic and stock watering
Riverton, WY	Fremont	63	1069	11738	Riverton	3mi	urban, mixed, IR*	local wells below 100 ft; limited use of shallower water

* Indian Reservation

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES

	Monument Valley, AZ	Tuba City, AZ
Location, Topography	The site is on the Navajo Indian Reservation in Cane Valley, east of Monument Valley, AZ. The area is arid desert with hills, steep ridges, and mesas. Red sandstone cliffs are prominent on the west edge of Cane Valley.	The site is on the Navajo Indian Reservation, 5.5 mi east of Tuba City in Coconino County, AZ, and 85 mi north of Flagstaff. The area includes occasional dry washes, mesas, and rolling hills.
Geology	The site is located in a strike-valley developed on shale members of the Chinle Formation. The site is bordered on the west by an outcropping of the Shinarump Member of the Chinle Formation and on the east by Comb Ridge, a hogback of resistant sandstones of Triassic and Jurassic age.	The tailings rest on a sand layer from less than 1 ft to 20 ft thick derived from the underlying Navajo Sandstone, a weakly cemented, medium-grained, crossbedded sandstone. The Navajo Sandstone dips at a low angle (2 deg) away from the town of Tuba City towards the axis of the Tuba City syncline. This axis runs in a northwest-southeast direction about 1 mi east of the tailings site. The Navajo Sandstone is exposed south of the millsite along Moenkopi Wash.
Surface Water Hydrology	There are no continually active streams in the area. The site drains naturally into Cane Valley Wash. Approximately 1,000 acres of land are in the drainage basin that passes through the tailings area to the wash.	There are no surface waters of consequence near the Tuba City tailings site. Surface drainage runs to the Moenkopi Wash about 1.5 mi south of the tailings. There is evidence of minor sheet erosion in the area. To the north of the highway, a large depression known as Greasewood Lake depression drains to the west-southwest.
Ground Water Hydrology	Unconfined ground water is very near the surface along the main axis of Cane Valley Wash because the area is underlain by impermeable beds of Monitor Butte and Petrified Forest members of the Chinle formation. These members consist of siltstones and claystones and are about 700 ft. thick in the millsite area. The unconfined water moves through the alluvium of Cane Valley Wash and is recovered near the site from shallow wells. These shallow wells and springs are water table sources and their recharge is from local runoff.	The principal aquifer in the Tuba City-Moenkopi area is a multiple aquifer system consisting of the Navajo Sandstone and some sandstone beds in the underlying Kayenta Formation. This aquifer is recharged by winter and spring precipitation in the Kaibito Plateau highlands some distance north of Tuba City. Water in the multiple aquifer system moves southward from the highlands; its principal discharge area is along Moenkopi Wash. Thus, the tailings are situated in the discharge rather than the recharge area of the aquifer system. Water in this multiple aquifer system is unconfined.
Waste and Soil Characteristics	The new tailings pile (85%) is coarse-grained sand and small pebbles containing less than 2% minus 200-mesh material. The old tailings pile (15%) is slightly finer. Bulk densities run between 97 and 103 lb/cu ft. Soil beneath both piles is mainly fine-textured sand containing little moisture. The Chinle Formation underlies this alluvium.	The tailings are finely ground particles, a high-clay content, relatively impermeable, and can hold water. The subsoil consists mainly of sand and small aggregate eroded from the underlying Navajo Sandstone.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Durango, CO	Grand Junction, CO
Location, Topography	The site is located on the southwest side of the city of Durango, in the valley of the Animas River. The area is surrounded by mesas and mountains typical of the western slopes of the Rocky Mountain Range.	The site is located on the south side of the city of Grand Junction, CO, on the north bank of the Colorado River and adjacent to the industrial center of the city. The site is located in the valley of the Colorado River, surrounded by generally arid mesas and mountains.
Geology	The site is on a shelf between the Animas River on the northeast and the sharply rising Smelter Mountain on the southwest. The tailings generally lie directly on Mancos Shale bedrock, but some of the piles are on alluvium and on slag from the old lead smelter. The bedrock strata dips 5 to 10 deg southeastward. The Mancos Shale is hundreds of feet thick beneath the tailings and acts as a barrier to the downward and upward migration of ground waters.	The site is located on the modern flood plain of the Colorado River. A relatively thin (200-ft) section of remaining Mancos Shale underlies the unconsolidated riverbed deposits and acts as a barrier to the downward and upward migration of ground water. The bedrock strata dip 5 to 10 deg toward the southwest.
Surface Water Hydrology	Flowing surface waters near the site consist of Lightner Creek and the Animas River. Neither an intermediate regional flood (100-yr flood) nor a more severe standard project flood would reach the tailings nor would such floods erode the slag bank material which provides excellent protection for the toe of the large pile. Even so, the potential for flooding at the present location is significant because of the nearness of the site to the Animas River.	Flowing surface waters near the site consist of the Colorado River, a drainage ditch, and several man-made facilities associated with earlier operations at the site. The Colorado River at Grand Junction has a long history of flooding. During an intermediate regional flood (100-yr flood) or a more severe standard project flood, the tailings pile would be an island surrounded by flood waters with unconfined ground water rising as much as 10 ft into the pile.
Ground Water Hydrology	The unconfined aquifers in the Durango area consist of waters within the recent valley alluvium and glacial deposits. However, it is possible that ground waters flowing through the unconsolidated material could be contaminated by any such seepage. The Mancos Shale acts as a virtually impermeable layer confining the waters of the Dakota Sandstone. There is no possibility for contamination of this potential aquifer.	The unconfined aquifers in the Grand Junction area consist of waters within alluvial deposits, terrace deposits, weathered rocks and soils, and in the Mancos Shale. The water table associated with the Colorado River fluctuates several feet during the year and may saturate some of the lowermost tailings. Any contamination due to water table fluctuations would be carried by unconfined ground waters into the Colorado River. The Mancos Shale acts as a virtually impermeable layer that confines the waters of the Dakota Sandstone and other stratigraphically lower aquifers.
Waste and Soil Characteristics	Materials consist of uranium and vanadium tailings, lead smelter slag, rubble, and contaminated earth. The tailings consist of grey, finely ground sands with a low clay content, and bulk densities of the material range between 95 and 102 lb/cu ft.	Materials include uranium and vanadium tailings, rubble, and contaminated earth. The tailings consist of gray, finely-ground sands and purple slimes. Bulk densities of the materials range between 70.1 and 109.9 lb/cu ft.

Table 3-2. DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Gunnison, CO	Maybell, CO
Location, Topography	The site is located on the southwest side of Gunnison, in the valley of Gunnison River and Tomichi Creek. The area is surrounded by mountains which rise to 12,000 ft above sea level.	The site is located approximately 25 mi west of the town of Craig, 5 mi north of the Yampa River in a rolling, sagebrush-covered area.
Geology	The site is located on flood plain gravels of the Gunnison River and Tomichi Creek. The unconsolidated river-run material underlying the site is at least 100 ft thick and probably 200 ft thick. Bedrock geology consists of Mesozoic sedimentary rocks that overlie Precambrian igneous and metamorphic basement.	The site is located on a gentle southwestern slope near the head of a small drainage system. The Browns Park Formation underlies the site and in turn is underlain by the Mancos Shale Formation. The Browns Park Formation primarily is composed of sandstone units, and some shale layers within the formation act as barriers to the downward and upward migration of ground waters.
Surface Water Hydrology	The tailings pile is located 1.5 mi from the confluence of the Gunnison River and Tomichi Creek. Flooding of the tailings as a result of peak discharges of these rivers is unlikely because the land surface at the tailings is 10 ft above the stream beds and the flood plains are extensive. Under unusual conditions, such as ice jams in the Gunnison River at the bridge of U.S. Highway 50, some of the tailings could become saturated by flood waters. The natural surface drainage from the site is to the southwest to the Gunnison River or to Tomichi Creek.	The Yampa River, 5 mi south, is the closest perennial stream flowing through the area downdrainage from the site. Drainage at the site includes diversion ditches around the pile and drainage channels into Johnson Wash, a dry tributary of Lay Creek. Lay Creek enters the Yampa River approximately 2.5 mi downstream of Johnson Wash. Other surface water near the site consists of standing water in the inactive Rob Pit.
Ground Water Hydrology	The unconfined ground water in the unconsolidated riverbed material of the valley floor is the major aquifer for city and private water supplies. The general direction of ground water flow parallels surface water flow to the southwest. The city's water supplies are upgradient from the pile. There are water wells southwest of the pile and a potential for additional ground water development. There has been no evidence of contamination of ground or surface waters, but there is a potential for such contamination.	The unconfined ground waters of the area are within the Browns Park Formation and in unconsolidated valley deposits. The water table at the site is 150 ft below the tailings-soil interface, and the flow gradient is to the west-southwest. The confined ground waters are either contained in the lower sections of the Browns Park Formation by shale layers, or are very deep aquifers confined by the thick sequence of Mancos Shale.
Waste and Soil Characteristics	The material consists of uranium tailings, dike material, and stabilization cover. The tailings are gray-to-white finely ground sands with a medium clay content; bulk densities of the material range between 114.6 and 127.5 lb/cu ft.	Finely-ground sands with some slime and slight clay contents. Bulk densities run between 84 and 97 lb/cu ft. The soil beneath the tailings consists of clayey and silty fine sands, of medium density.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Naturita, CO	Rifle, CO (Old Rifle, New Rifle)
Location, Topography	The site is located 2 mi northwest of the town of Naturita, in the San Miguel River Valley. The locale is arid with canyons, mesas, steep cliffs, and valleys.	The original tailings site was just east of Rifle; later disposal was on land about 2 mi west of Rifle. Both sites are on the north bank of the Colorado River.
Geology	The site is located on the west bank of the modern flood plain of the San Miguel River, which flows northwestward through the narrow San Miguel River Valley. Approximately 50 ft of alluvium overlie the shales, sandstones, and conglomerates of the Brushy Basin Member of the Morrison Formation. Bedrock strata dip 2 to 4 deg northeastward. The Brushy Basin Member is 100 to 200 ft thick and is underlain by the sandstones and shales of the Salt Wash Summerville Formation.	The sites are on unconsolidated Colorado River alluvium, underlain by the Shire Member of the Wasatch Formation. In this area the member is characterized by up to 1600 ft of thick impermeable claystone and siltstone beds. Geologic structure includes the Piceance Basin north and west of Rifle and the White River uplift northeast. The Wasatch Formation dips 3 deg or less to west or northwest at the site.
Surface Water Hydrology	Flowing surface waters adjacent to or near the site consist of the San Miguel River and intermittent streams that drain the neighboring canyons. Waters have flowed onto the former pile area from the diversion ditch along the southwestern border of the site and from drainage at the northwest of the site. The area has been inundated by flood waters since the tailings were removed.	Surface water at the sites include drainage ditches, water-accumulation ponds, and some marsh areas. Both sites are in the floodplain of the Colorado River. The main channel has undergone six major redirections in the past 100 years because of major floods. Computed flows are 45,000 cfs for 100-year flood and 65,000 cfs for 500-year flood but, because of the wide floodplain in this area, flood velocities would be on the order of 3 feet per second.
Ground Water Hydrology	The unconfined aquifers in the San Miguel River Valley consist of waters within the recent valley alluvium. Except during flooding season, the water table lies 3 to 10 ft below the former tailings-subsoil interface. During an intermediate regional flood or more severe floods, the water table would rise within the alluvium. Potential confined ground water aquifers consist of sandstone strata within the Morrison Formation and the sandstone units within the Entrada Formation. The Summerville Formation separates the Morrison Formation from the Entrada Formation and prevents downward migration of water.	Both bedrock and alluvial groundwater subsystems are present. The bedrock system, the Molina Member of the Wasatch is under artesian pressure and probably provides a small recharge to the alluvial system. At the old site alluvial ground water represents a small, nearly isolated system recharged by flow from the river, precipitation, and return irrigation flows. A ground water mound beneath the pile keeps the tailings saturated even during periods of low water. At the new site the alluvial aquifer is recharged by infiltration from the Colorado River, precipitation, side-channel flow, and seepage from Rifle sewage facilities.
Waste and Soil Characteristics	The tailings were removed from the site and reprocessed. The soil beneath the former tailings pile area is composed of alluvial deposits of the San Miguel River.	Materials include uranium and vanadium tailings, rubble, contaminated earth and stabilization cover. The tailings are on unconsolidated Colorado River alluvium 16 to 21 ft thick at the old site and 20 to 25 ft thick at the new site.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Slick Rock, CO (Union Carbide, North Continent)	Lowman, ID
Location, Topography	Two sites, the Union Carbide Corporation (UC) site and the North Continent (NC) site, about 0.9 mi apart. The sites are located approximately 25 mi north of Dove Creek, CO, and 3 mi northwest of Slick Rock, CO, in the Dolores River Valley.	The site is located approximately 75 mi northeast of Boise, ID, in a pine-covered mountain valley in the Boise National Forest, on a west-facing terrace of the Sawtooth Mountain Range. Drainage from the site is into Clear Creek .
Geology	The sites are located on the flood plain of the Dolores River. Bedrock consists of sedimentary strata: Navajo Sandstone at the UC site and the Salt Wash Member of the Morrison Formation at the NC site. The bedrock strata dip gently to the northeast.	The site is located on a glacial terrace, incised by Clear Creek. A lower river-laid terrace, on which a settling pond area was constructed, is adjacent to the higher millsite terrace. The glacial terrace material is composed of deep sandy and loamy soils, gravels, sands, boulders, and cobbles. The lower alluvial terrace is river-run material. Igneous granite bedrock (granodiorite), underlies the site.
Surface Water Hydrology	The flowing surface waters near the sites consist of the Dolores River and three of its tributaries. An intermediate regional flood (100-yr flood) or larger flood would inundate the base of the piles and could erode part of the UC dike earth cover and possibly the tailings themselves. The flow of flood waters across the base of the NC site would not be as swift. Overland flow across the piles is limited almost entirely to the precipitation that falls on the piles.	Flowing surface waters near the site include Clear Creek, the South Fork Payette River, and intermittent flow in ditches on the site. Clear Creek, a swiftly flowing stream, intersects the South Fork Payette River approximately 0.5 mi south of the site. The lower terrace which borders the creek could be eroded by flood waters of Clear Creek, with resulting undercutting and erosion of the piles. Erosion at the site, aggravated by the steep banks of the piles, has resulted in gullies up to 10 ft deep.
Ground Water Hydrology	Contamination of confined water systems theoretically is possible because the bedrock strata are permeable and waters of the Dolores River recharge the aquifers. The quantity of recharge from the Dolores River would dilute any leaching from the tailings piles.	Local aquifers are shallow and unconfined. Clear Creek and the South Fork Payette River are gaining streams fed by flows from unconfined ground waters. The terrace materials tend to filter sediments from the waters and act as buffers to regulate overland and subsurface flow. The interface between the unconsolidated surficial materials and bedrock acts as the surface for lateral ground water flow. Seeps and springs are common in the area, particularly at the exposure of this interface.
Waste and Soil Characteristics	The UC tailings are coarse-grained sand, while the NC tailings are finer-grained with a clay content. Bulk densities run between 88 and 97 lb/cu ft.	The materials are angular, dense, coarse-grained sands; some gray and white, black (magnetite) and red (garnet). The underlying soil is mountain loam, nearly black in color, with gravelly aggregates resulting from glacial deposits in some locations.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Ambrosia Lake, NM	Shiprock, NM
Location, Topography	The site is located in a valley 25 mi north of Grants and 85 mi northwest of Albuquerque, NM. Mesas and steep cliffs surround the valley and reach elevations about 200 ft above the site.	The site is located on the Navajo Indian Reservation, on the south side of the San Juan River at the town of Shiprock, NM. The area is arid and desert-like, with low rolling hills and occasional steep ridges and mesas.
Geology	The site is on a pediment sloping southwestward from the base of San Mateo Mesa. The underlying Mancos Shale bedrock dips gently toward the northeast, opposite the direction of surface drainage, and acts as a barrier to the downward and upward migration of ground water in bedrock. Unconsolidated materials separating the tailings pile from bedrock are composed of clays and silts, contain some water, and do not exceed 15 ft in thickness.	The site is situated on an ancient river terrace adjacent to the southwest bank of the San Juan River. Up to 10 ft of terrace deposits form a layer between the Mancos Shale and the tailings. The materials are poorly sorted and range in size from 12-in boulders to sand- and silt-sized particles that are cemented together in places. The Mancos Shale directly below this alluvium is at least several hundred feet thick.
Surface Water Hydrology	There are no perennial surface streams near the site. Dry washes drain near the site and some runoff can flow toward the site. Surface waters near the site include ponded waters on the tailings pile itself and near the mill. Tailings have been eroded from the pile by storm runoff.	The elevated topography at the millsite eliminates the possibility of flooding or erosion of the tailings by the waters of the San Juan River. South and west of the tailings, the terrain is relatively flat near the site. Drainage from the higher ground farther to the south is carried to Dead Mans Wash, which empties into the San Juan River about 0.5 mi southeast of the site.
Ground Water Hydrology	The tailings lie on unconsolidated materials which contain some unconfined ground waters. Seepage through the pile is possible. The confined ground waters of the area are protected by Mancos Shale from the downward flow of contaminants from the tailings pile. The Dakota Sandstone underlies the Mancos Shale and is a potential aquifer. The Westwater Canyon Sandstone Member of the Morrison Formation is tapped as the major aquifer in the area, which is unusual since it serves as the chief uranium-bearing horizon of the vicinity.	The confined ground water aquifers underlying the site are protected against contamination by both an upward pressure gradient and thick impermeable strata. There is a potential for further contamination of the terrace gravel immediately underlying the tailings piles if sufficient water is allowed to collect and percolate through the piles.
Waste and Soil Characteristics	The tailings are white to pink finely-ground sand with some clay; bulk densities range from 100 to 108 lb/cu ft. Material beneath the site is a thin alluvial layer of clay and silt derived from the surrounding highlands.	Materials include a combination of uranium and vanadium tailings, dike material, rubble, and stabilization cover of pit-run gravel. Bulk densities range between 82 and 107 lb/cu ft. The soil on the site is a combination of decomposed shale and a conglomerate of river-deposited sand and cobbles.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Lakeview, OR	Canonsburg, PA
Location, Topography	The site is located in Goose Lake Valley 96 mi east of Klamath Falls, OR. Mountains surrounding the site on the east and west reach elevations of 8,000 ft.	The site is located within the corporate limits of the borough of Canonsburg, PA. The site slopes to the east toward Chartiers Creek.
Geology	The Lakeview site is located in an unconsolidated valley fill consisting of clays, sands and gravels that overlie sedimentary rocks of lacustrine and fluvial origin. The site is at the eastern boundary of the Goose Lake Graben, which is block-faulted by northerly and northeasterly normal faults.	The unconsolidated materials at the site are of fluvial origin. Underlying these deposits are sedimentary strata of the Pennsylvanian System, consisting of sandstone with a little conglomerate, shale, limestone, clay, and numerous beds of coal. The site lies on top of the Conemaugh Formation, which is predominantly shale with abundant sandstone beds and some limestone, clay, and coal.
Surface Water Hydrology	The surface waters near the site consist of drainage ditches, ponded water after rains, and an unnamed stream from Hammersley Canyon that is routed between the tailings pile and the adjacent evaporation ponds. There is no evidence that the stream flow has eroded the tailings pile or the embankments surrounding the evaporation ponds.	Abundant surface waters in the area include several streams, numerous intermittent drainages, and several reservoirs and ponds. Surface waters in the vicinity of the site include Chartiers Creek and several ditches which carry runoff. At a gauging station in Carnegie, about 12 mi northeast of Canonsburg, the annual average flow of Chartiers Creek was recorded at 287 cfs. The estimated annual average flow of Chartiers Creek in Canonsburg is between 90 and 130 cfs.
Ground Water Hydrology	Ground water occurs under confined and unconfined conditions. There is a strong upward flow gradient from leaky artesian aquifers in the thin, unconsolidated lacustrine sediments. Contamination of the ground water is unlikely. A known geothermal area is located adjacent to Warner Mountain, and the surface water temperature at Hunters Hot Springs, 1 mi northwest of the site, is 212 F.	Confined ground-water systems in the Conemaugh Formation under the site occur largely in the sandstone beds with limited quantities in the bedding-plane passages and in joint planes of the shales and limestones. Yields are variable and unpredictable but generally range from small to moderate. A median yield for wells in this aquifer is 5 gal/min. Yields large enough for industrial or municipal purposes are difficult to obtain. Unconfined ground water at the site is found in fill materials and in alluvial deposits.
Waste and Soil Characteristics	The uranium tailings are of a fine brown sand. The natural soil on which the tailings rest is a rich dark brown-to-black loam.	Tailings have been stabilized in place.

Table 3-2. SUMMARY DESCRIPTIONS OF INACTIVE URANIUM MILL TAILINGS SITES (cont'd)

	Belfield, ND	Bowman, ND
Location, Topography	The site is located about 19 mi west of Dickinson, ND, on nearly level land immediately south of the North Branch of the Heart River. The Heart River, an intermittent stream, flows generally west to east in a channel 10 to 15 ft below the general elevation of the site.	The site is at the Griffin siding about 7 mi west of Bowman. It is on nearly level land near the head of Spring Creek, a part of the Grand River drainage basin. An intermittent drainage to the west joins Spring Creek less than 0.5 mi southwest of the site.
Geology	The site is located on alluvial deposits of the Heart River which are largely silt and clay with a few beds of sand and gravel. Underlying bedrock is poorly consolidated. A lignite bed occurs at 50 ft depth. In many localities scoria beds are present, from burned lignite beds.	The site is underlain by the Bullion Creek Formation, sometimes called the Tongue River in this area. The formation consists of light layers of silt, clay, and sand with interbedded sandstone, lignite, baked clay, and limestone.
Surface Water Hydrology	The site is located on the south side of the north branch of the Heart River. In the vicinity of the site, the river is an intermittent stream draining only a small area. During summer months there may be areas of stagnant water in the streambed. Surface flows arise only from rainfall directly on the site. Precipitation on the site drains either to the Heart River or to ponds on the site.	The site is located 1 mi north of Spring Creek in the headwaters of the North Fork of the Grand River, a tributary of the Missouri River. A small intermittent drainage runs along the west side of the site and joins Spring Creek 0.5 mi southwest of the site. Precipitation tends to pond in local low spots and generally evaporates with some infiltration into the clayey-silty soils on the site. Numerous small reservoirs in the vicinity of the site are generally used for stockwater, irrigation, and recreation.
Ground Water Hydrology	There are four major usable aquifer systems underlying the site. The uppermost, the Sentinal Butte Formation, outcrops much of the area and supplies rural livestock and domestic wells. The next lower system, the Ludlow and Tongue River, is probably comprised of several aquifers. The upper aquifers may be unconfined, are interconnected with and recharge the lower part of the system. The Upper Hell Creek and Lower Cannonball-Ludlow Formation form the third aquifer system and is not extensively tapped in this area. The lowermost system, the Fox Hills and Basal Hell Creek Formation, is not heavily used in this area but is tapped by two Belfield city wells. The minimal water in the alluvial deposits on the Heart River in this area may contribute to local wells. The water table is about 40 ft below the surface.	There are four major usable aquifer systems beneath the site. These include from highest down, the Upper Ludlow and Tongue River Aquifer, Middle Ludlow Aquifer System, Upper Hill Creek and Lower Ludlow Aquifer System, and the Fox Hills and Basal Hill Creek System. The upper three are locally interconnected, with recharge from precipitation and seepage from surface waters and are used locally for domestic and stock purposes. The lower aquifer, Fox Hills and Basal Hill Creek System, is recharged by percolation from overlying beds, is most reliable and serves municipal needs.
Waste and Soil Characteristics	No mill material is present; all ash from the kiln was shipped to Rifle, CO. However, radiation measurements showed that most of the surrounding soil at the site is contaminated to depths of 6 to 12 in, locally to 4 ft. The soils present on the site are Savage silty clay loams; soil and subsoil are 2 to 3 ft thick.	Mill materials (ash from the kiln) was collected and shipped to Grants, NM, for further processing. The soil at the site is contaminated to depths of about 3 ft. Soils are silts and clays up to 7 ft in depth, with sands below that. Bedrock is not consolidated and is less than 20 ft below the surface, at which depth a coal bed is located.

TABLE 3-5. AVERAGE CONCENTRATION OF ELEMENTS FOUND IN INACTIVE URANIUM MILL TAILINGS (a)
(in ppm)

Tailings Pile	As Arsenic	Ba Barium	Cd Cadmium	Cr Chromium	Cu Copper	Fe Iron	Pb Lead	Hg Mercury	Se Selenium	Ag Silver	U Uranium	V Vanadium	Zn Zinc	Ra-226[b] Radium (x 10^{-6})
Arizona														
Monument Valley	1.5	-	-	-	-	-	--	--	0.064	--	60	1850	--	50
Tuba City	82	86	4	6	1160	7230	812	0.001	10	6	370	620	249	920
Colorado														
Durango	0.80	82	0.20	8.8	95	62	62	0.87	1.2	1.2	480	3900	304	700
Grand Junction	14	121	1.6	29	14	1170	50	0.026	3.1	0.72	180	1760	45	780
Gunnison	254	66	0.26	5.2	30	20800	137	--	1	3.8	90	80	120	420
Maybell	1.5	18	0.09	9.3	3.1	2100	13	0.09	13	0.15	120	120	17	274
Naturita	59	172	0.07	3.5	54	16400	48	--	0.47	1.1	500	2890	75	--
New Rifle	4.2	100	1.1	55	8	807	187	0.001	1.9	1.4	240	3990	31	870
Old Rifle	3.7	155	8.7	20	18	8250	38	0.25	2.7	0.46	380	520	359	1000
Slick Rock NC	34	453	0.027	4.9	35	6540	1250	109	0.76	1.7	80	620	21	780
Slick Rock UC	6.6	134	0.074	3.4	17	4080	29	0.074	2.2	0.57	50	1480	21	690
New Mexico														
Ambrosia Lake	2.6	96	3.6	8	58	90	--	0.002	68	0.15	210	1590	47	640
Shiprock	0.004	-	-	-	-	-	--	--	0.18	--	120	330	--	700
Utah														
Green River	1.9	73	0.40	17	102	1210	121	0.001	231	0.070	60	1390	21	810
Mexican Hat	63	12	0.70	1.0	488	3650	40	--	6	1.0	140	1350	57	780
Vitro Uranium[c]	210	2130	-	1010	310	31100	3060	--	--	0.022	180	100	340	
Vitro Vanadium[c]	244	3860	-	2030	1080	213000	350	--	--	0.066	50	830	350	900
Wyoming														
Spook	87	46	0.37	26	14	15299	2.5	--	262	2.2	130	350	31	340
Riverton	161	64	0.32	23	21	21800	3.2	--	391	2.4	70	240	38	560
"Typical" Soil[d]	6	500	0.06	100	20	38000	10	0.03	0.2	0.1	1.0	100	50	1.5

(a) Adapted from G. Markos and K.J. Bush, "Physico-Chemical Processes in Uranium Mill Tailings and Their Relationship to Contamination" (Mac81a)
(b) Table 3-1 (1 pCi/g = 1 x 10^{-6}ppm, for Ra-226).
(c) Two different parts of the Vitro Site, Salt Lake City, Utah.
(d) Bo66.

TABLE 3-6. GROUND WATER MATRIX

SITE GROUND-WATER CHARACTERISTICS	AMBROSIA LAKE, NM	BELFIELD, ND
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	Primarily in alluvium & Tres Hermanos-C; may eventually discharge into Westwater Canyon. Approximate volumes: Alluvium - 450 million gal. Tres H.C - 225 million gal.	Sentinel Butte Formation, extent not yet determined.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Most samples exceed standards for Co,Mn,Mo,Radium,504, and TDS A small # of samles exceed stds for As,B,Cd,Cl,Cr,F,G Alpha,Fe, NO3,pH,Se,Ag, and U.	Not yet determined.
NATURAL GROUND-WATER QUALITY	The alluvium and Tres Hermanos-C sandstone were probably unsaturated prior to mining and milling.	High concentration of SO4, TDS
EXISTING USE OF GROUND WATER	None in alluvium & Tres Hermanos sandstone:Westwater Canyon sandstone is major water supply.	Stock wells, some domestic wells mostly for purposes other than drinking.
FATE OF THE PLUME(S)	Eventual discharge to mine shafts and vents into Westwater Canyon Sandstone.	Possible discharge to the Heart River.
FEASIBILITY OF INSTITUTIONAL CONTROLS	Because only unused and unusable groundwater has been and will be significantly impacted there is no need for inst. controls.	State of North Dakota requires well permits for domestic wells.
ALTERNATE DISPOSAL SITE	None.	Bull creek or stabilization with tailings at Bowman, ND.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	N/A	Bull Creek - 50 feet Bowman - 10 to 15 feet
WATER QUALITY AT ALTERNATE SITE	N/A	Bowman - high SO4, TDS Bull Creek - unkown, probably similar to Belfield and Bowman
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	N/A	Minimal.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE.	Grants, NM - 8 miles.	Belfield, ND - 1/2 mile.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	BOWMAN, ND	CANONSBURG, PA
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	Tongue River Formation, extent not yet determined.	Onsite in alluvium. May extend into upper shale/limestone bedrock. Some indication of slight contamination. Volume approx. 100 million gal.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Not yet quantified.	Cosntituents above standards in onsite, alluvial waters are: Cl, SO4, and TDS.
NATURAL GROUND-WATER QUALITY	High concentration of SO4, TDS	Background alluvial water sample NO3 exceeds standard.
EXISTING USE OF GROUND WATER	Stock wells and a few domestic wells, not normally used for drinking.	Limited use, primarily for gardening. Note: More data will be forthcoming from S&M monitoring.
FATE OF THE PLUME(S)	To be determined.	Probably discharging to Chartier Creek although there maybe some underflow in shallow bedrock.
FEASIBILITY OF INSTITUTIONAL CONTROLS	State of North Dakota requires well permits for domestic wells.	High feasibility given limited use & discharge of contamination to Chartiers Creek at site bound
ALTERNATE DISPOSAL SITE	Bull Creek, approximately 50 miles north of Bowman.	N/A
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	50 feet.	N/A
WATER QUALITY AT ALTERNATE SITE	Unknown, likely to be similar to the background water quality at Bowman and Belfield.	N/A
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	Minimal.	N/A
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS SITE.	Bowman, ND - 7 miles.	Canonsburg, PA - in town.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	DURANGO, CO	FALLS CITY, TX
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	DURO1 (piles) - alluvium: approx- 50 acres x 20-30 feet deep. DURO2 (ponds) - alluvium: approx- 55 acres x 30-40 feet deep. Menefee Fm. one well 50-70' deep	Unconfined system (Dewesville/ Conquista) 700 ac x 60-70 feet. approx. 4 billion gallons. Semi-confined (Dilworth): contamination in 2-4 wells, 120 to 150 feet deep.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	DURO1 - alluvium: CL-4x, Fe-2x, As-100x, Se-100x, SO4-15x, U(6.2mg/ DURO2 - alluvium: Cl-5x, As-5x, Se-40x, SO4-115x, U(2.4mg/L) DURO2 - Menefee Fm: Cl-6x, Se-2x	Unconfined system: Cl-23x, Fe-40x Mn-200x, SO4-20x, TDS-26x, Ra-226 (100pci/L), U(67mg/L) Semi-confined system: Cl-4x, SO4-8x, TDS-15x, U(3.2mg/L).
NATURAL GROUND-WATER QUALITY	slightly elevated Cl, Fe, TDS, U but drinking water quality	SO4, Cl, Fe, Mn, TDS exceed drinking water stds, U= 100-300 ppb.
EXISTING USE OF GROUND WATER	No current users within two miles downgradient.	Four livestock wells within two miles. No domestic consumption.
FATE OF THE PLUME(S)	Discharge to Animas River within 100 to 500 feet of the piles and ponds.	Discharge to San Antonio R. NE of site in 150 to 200 years. Discharge to Borrego Cr. SW of site in 300 to 400 years.
FEASIBILITY OF INSTITUTIONAL CONTROLS	Have been recommended to the state.	State of Texas requires well permits for domestic wells.
ALTERNATE DISPOSAL SITE	Bada Canyon	Not evaluated.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	20 to 40 feet	N/A
WATER QUALITY AT ALTERNATE SITE	SO4, TDS, Fe, Mn exceed drinking water standards.	N/A
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	Minimal; shallow system discharges to Animas River within two miles of the site.	N/A
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS SITE	Durango, Colorado - 1.5 miles NE of Bada Canyon site	Falls City, Texas - 9 miles NE of tailings site.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	GRAND JUNCTION, CO	GREEN RIVER, UT
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	From the site to the west, up to 1/2 mi downgradient of site in alluvium. Some cntmts. may enter Dakota Ss @ subcrop 1/2 mi west.	Brown's Wash Alluvium - <= 9 ac x 7 feet Cedar Mountain Fm. - <= 9 ac x 25 feet.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Relative to stds and background, the 5 critical contaminants are: Cl,F,Fe,SO4, and Cd.	Alluvium - NO3-11x, NH4(40mg/L), U(1.19mg/L),Mn-10x. Cedar Mtn. Fm. - NO3-11x, NH4(30mg/L), U(1,86mg/L), Mn-25x
NATURAL GROUND-WATER QUALITY	Most background samples exceed standards for Cl,Fe,Mn,SO4,& TDS	Not suitable for drinking water. High conc. of TDS, SO4, Cl, Se, F.
EXISTING USE OF GROUND WATER	No known use of alluvial or Dakota sandstone water.	None.
FATE OF THE PLUME(S)	Discharge to the Colorado River or enter the Dakota SS and disperse through space and time.	Alluvium - discharge into Brown's Wash approx 400 feet from pile. Cedar Mtn. Fm. - no discharge point identified. Plume will disperse in this aquifer.
FEASIBILITY OF INSTITUTIONAL CONTROLS	Highly feasible: 1)The site is w/in a municipality. 2)Contaminated water has not been used & has limited value.	State of Utah requires well permits for domestic use.
ALTERNATE DISPOSAL SITE	Cheney Reservoir	Recommended stabilization on site
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	Approximately 30 feet.	N/A
WATER QUALITY AT ALTERNATE SITE	Brackish. Seasonally perched.	N/A
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	No impact on any potential water resource.	N/A
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS SITE	Grand Junction, CO - in town.	Green River, UT - 1 mile NW of site.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	GUNNISON, CO	LAKEVIEW, OR
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	approximately 1 sq. mile; depth (thickness) approx. 100 ft Volume approx. 2 billion gal.	Approx 1/4 to 1/2 mile downgradient to 50-75 ft depth in unconsolidated deposits. Volume approx. 3 billion gal.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	U(1.1 mg/L), NO3-3x, SO4-7x, Se-10x, Fe-50x (based on max. values.)	As,B,Cl,F,Mn,SO4,& TDS standards are exceeded in many onsite and downgradient shallow sample. Cd Fe, & pH are exceeded in a few instances. The exceedances are rarely greater than 10 times std
NATURAL GROUND-WATER QUALITY	Potable, TDS-300 mg/L.	Non-geothermal background is potable,except Mn std exceeded in some cases. Geothermal bckgrd exceeds std for As,F,& TDS.
EXISTING USE OF GROUND WATER	Domestic.	Considerable use for domestic, agricultural,municipal,industry. Most use is at depth >100 ft.
FATE OF THE PLUME(S)	Disperse to below drinking water standards. Discharge to Gunnison R. & Tomichi Creek.	Disperse & dilute as the contaminants move downgradient in the unconsolidated deposits.
FEASIBILITY OF INSTITUTIONAL CONTROLS	The state of Colorado requires well permits for domestic use.	The contaminant levels are low enough that only shallow ground water close to the site may need to be controlled. Therefore institution controls are feasible
ALTERNATE DISPOSAL SITE	East Gold Basin.	Collins Ranch.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	100 - 200 feet.	Greater than 30 feet.
WATER QUALITY AT ALTERNATE SITE	Potable, TDS-600 mg/L.	Potable without treatment.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	Under evaluation.	Minimal impact; i.e.,stds should not be exceeded at closest well for at least 1000 yrs.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Gunnison, CO - 1000 ft.	Lakeview, OR - in town.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	LOWMAN, ID	MAYBELL, CO
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	To be determined.	To be determined in FY87.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	To be determined.	U, NO3, SO4, Cl, and possibly trace elements (As, Se, Mo) are constituents of tailings seepage Site hydrogeological conditions are not complete & solutes that exceed Standards not yet known.
NATURAL GROUND-WATER QUALITY	Drinking water quality TDS < 250 mg/L.	Possible drinking water quality. TDS as high as 1200 mg/L.
EXISTING USE OF GROUND WATER	Surface and ground water used for drinking water supplies.	Ground water within the alluvium used for drinking water supply in Maybell. Browns Park Fm. is a regional source of drinking water supply.
FATE OF THE PLUME(S)	To be determined.	To be determined.
FEASIBILITY OF INSTITUTIONAL CONTROLS	To be determined.	State of Colorado requires well permits for domestic wells.
ALTERNATE DISPOSAL SITE	Possibly along Highway 21, east of the tailings, not yet positively identified.	Johnson Pit - located approx. 0.25 mile south of tailings site.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	Unknown.	Unknown.
WATER QUALITY AT ALTERNATE SITE	Unknown, probably similar to Lowman.	Unknown, possibly similar to Maybell.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	Unknown.	Unknown.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Lowman, Idaho - 1/4 mile.	Maybell, CO - 7.3 miles SW.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	MEXICAN HAT, UT	MONUMENT VALLEY, AZ
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	300 acres x 40 feet.	570 acres x 80 feet.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Mn-26x, NO3-2x, SO5-9x, TDS-8x U(0.43 mg/L)	NO3-24x, SO4-6x, U(0.03 mg/L) Mn-12x, TDS-7x
NATURAL GROUND-WATER QUALITY	High conc. of SO4 and TDS; unsuitable for drinking water.	Drinking water quality TDS < 500 mg/L.
EXISTING USE OF GROUND WATER	None.	A few handpump wells for local residents.
FATE OF THE PLUME(S)	Seepage into Gypsum wash and movement to San Juan R. No contamination in the river.	Natural dispersion, 20 to 200 yr to reach background. Possibly some discharge to Cane Valley Wash during storms.
FEASIBILITY OF INSTITUTIONAL CONTROLS	Navajo Tribe requires well permits for domestic wells.	Navajo Tribe approves/records all wells.
ALTERNATE DISPOSAL SITE	Not evaluated.	Yazzie Mesa approx. 1/2 mile southwest of the tailings.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	N/A	160 feet.
WATER QUALITY AT ALTERNATE SITE	N/A	Drinking water quality TDS < 500 mg/L.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	N/A	Minimal; water table separated from tailings by relatively impermeable Moenkopi Formation.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Mexican Hat, Utah - one mile. Halchita, Utah - 0.25 miles.	Mexican Hat, Utah.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	NATURITA, CO	RIFLE, CO
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	Alluvium - 73 ac x 20 feet. 95 million gallons.	RFO - alluvium, 9 ac x 30 feet RFN - alluvium, 400 ac x 30 feet RFN - Wasatch Fm., 150 ac x 50 ft.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Fe-3x, Mn-65x, SO4-4x, TDS-4x, U(2.5mg/L)	RFO - alluvium SO4-10x; TDS-10x; U (2.08 mg/L) RFN - alluvium NO3-19x; SO4-100x TDS-80x; U(1.3mg/L); Mo(12.0mg/L NH4(6100 mg/L) RFN - Wasatch SO4-104x; NO3-2x; TDS-76x; NH4(2900 mg/L); U(0.76 Mo(5 mg/L)
NATURAL GROUND-WATER QUALITY	Marginally suitable for drinking water. SO4 and TDS slightly above standards.	High conc. of SO4, Mn, Fe, NH4, Cl, TDS. Unsuitable for drinking water.
EXISTING USE OF GROUND WATER	None.	Wasatch aquifer not used. Alluvial sq. used for livestock and irrigation. City uses Colorado River water.
FATE OF THE PLUME(S)	Discharge into adjacent San Miguel River.	Natural seepage to river adjacent to both sites. Return to backgrn in a minimum of 2yrs for RFO and 45yrs for alluvium at RFN.
FEASIBILITY OF INSTITUTIONAL CONTROLS	State of Colorado requires well permits for domestic wells.	State of Colorado requires well permits for domestic wells.
ALTERNATE DISPOSAL SITE	Not evaluated.	Estes Gulch, ground water not used in a 2 mi. radius of site.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	N/A	> 280 feet through Wasatch.
WATER QUALITY AT ALTERNATE SITE	N/A	Unknown.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	N/A	None. 800 yr travel time to first possible ground water.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Naturita, Colorado - 2 miles.	Rifle, Colorado - Tailings adjacent to city.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	RIVERTON, WY	SALT LAKE CITY, UT
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	From site to the Little Wind river(approx. 1/2 mile) through the alluvium & unconfined SS (approx. 20 ft thick). Volume approx. 1 billion gal.	From site possibly to the Jordan River and Mill Creek in the unconfined aquifer to depth of approx. 30 to 40 feet. Volume approx. 1.5 billion gal.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Key contaminants w/ exceedence of stds are Fe,Mn,SO_4,Cl,and a few samples of exceedences for radium and selenium. U as high as 2 mg/L, & Mo max is 4 mg/L.	Key contaminants are: As, Cl, Fe, WO_4, TDS, and Gross Alpha.
NATURAL GROUND-WATER QUALITY	Brackish in alluvium.	
EXISTING USE OF GROUND WATER	Minor stock watering.	None in unconfined system.
FATE OF THE PLUME(S)	Discharge to Little Wind River.	Discharge tot he Jordan River and Mill Creek.
FEASIBILITY OF INSTITUTIONAL CONTROLS	High feasibility because limited use or potential use of alluvial ground water.	High feasibility due to lack of existing & potential use and availability of public water supply.
ALTERNATE DISPOSAL SITE	American Nuclear Corporation in Gas Hills.	Clive, Utah.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	Unknown.	Approximately 30 to 40 feet.
WATER QUALITY AT ALTERNATE SITE	Unknown.	Brackish.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	Unknown.	None on potential water resource.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Riverton, WY - 3 miles.	South Salt Lake - in town.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	SHIPROCK, NM	SLICK ROCK, CO
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	Beneath site & below site in floodplain alluvium. Depth is 10 to 30 ft, to top of competent Mancos Shale. Floodplain vol. Onsite approx. 850 million gal.	NC Site - 23 acres x 20 feet. 30 million gallons. UC Site - 17 acres x 20 feet. 23 million gallons.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	Significant exceedences of stds for Cl,Cr,Mn,NO3,Se,SO4,and TDS, U(3.5 mg/L).	NC site: Fe-9x,Mn-9x,SO4-5x, TDS-5x,U(2.5mg/L) UC site: NO3-34x,Cl-1.1x,Fe-8x, Mn-51x,SO4-7x,TDS-8x, U(0.09 mg/L).
NATURAL GROUND-WATER QUALITY	On escarpment, poor to non-existent; on floodplain, slight exceedence of SO4 & TDS stds.	Alluvium - high conc. of Mn, SO4 TDS. Not drinking water quality. Navajo Ss. - drinking water qual.
EXISTING USE OF GROUND WATER	Some domestic use and potential municipal use of floodplain ground water and San Juan River water.	No use of alluvial ground water. Navajo aquifer supplies all needs.
FATE OF THE PLUME(S)	Appears to be relatively stagnant but eventually should discharge to the San Juan River.	Discharge into adjacent Dolores River.
FEASIBILITY OF INSTITUTIONAL CONTROLS	Could be fenced, plus the Navajo Tribe has a well permit requirement.	State of Colorado requires well permits for domestic wells.
ALTERNATE DISPOSAL SITE	N/A	Disappointment Valley.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	N/A	approx. 40 feet below land surface in Mancos Shale.
WATER QUALITY AT ALTERNATE SITE	N/A	High TDS reported. Unsuitable for drinking water.
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	N/A	Not evaluated.
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Shiprock, NM - in town.	Naturita, CO - approx 46 miles.

TABLE 3-6. GROUND WATER MATRIX (cont'd)

SITE GROUND-WATER CHARACTERISTICS	SPOOK, WY	TUBA CITY, AZ
AREAL AND VERTICAL EXTENT OF GROUND-WATER CONTAMINATION	To be determined in 1987.	110 acres x 110 feet of the Navajo Sandstone. Approx. 1.2 billion gallons.
NATURE AND DEGREE OF CONTAMINATION RELATIVE TO DRINKING WATER STANDARDS	To be determined in 1987.	NO_3-34x; SO_4-9x; U-0.45 mg/L; Fe-2x; Mn-13x; TDS-12x.
NATURAL GROUND-WATER QUALITY	Drinking water quality.	Drinking water quality. TDS < 500 mg/L.
EXISTING USE OF GROUND WATER	Domestic, agricultural, and livestock use.	Municipal well field for Tuba City is 5 mi. from site. One domestic well is 1.5 mi. cross-gradient.
FATE OF THE PLUME(S)	To be determined in 1987.	Discharge to Moenkopi Wash 10,000 feet from leading edgee of plume. First arrival of plume at Wash in 100 years.
FEASIBILITY OF INSTITUTIONAL CONTROLS	State of Wyoming.	Navajo Tribe approves/records all wells.
ALTERNATE DISPOSAL SITE	None.	None.
DEPTH TO WATER TABLE AT ALTERNATE DISPOSAL SITE	N/A	N/A
WATER QUALITY AT ALTERNATE SITE	N/A	N/A
EXPECTED IMPACT ON WATER QUALITY AT ALTERNATE SITE	N/A	N/A
NAME OF NEAREST CITY, DISTANCE FROM TAILINGS PILE	Douglas, WY - approx. 45 miles.	Tuba City, AZ - approx. 5 miles.

REFERENCES

1. Ford, Bacon & Davis Utah, Inc. April 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Vitro Site, Salt Lake City Utah. DOE/UMT-0102, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

2. Ford, Bacon & Davis Utah, Inc. June 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Durango Site, Durango, Colorado. DOE/UMT-0103, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

3. Ford, Bacon & Davis Utah, Inc. July 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Grand Junction Site, Grand Junction, Colorado. DOE/UMT-0105, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

4. Ford, Bacon & Davis Utah, Inc. July 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Naturita Site, Naturita, Colorado. DOE/UMT-0112, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

5. Ford, Bacon & Davis Utah, Inc. July 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Shiprock Site, Shiprock, New Mexico. DOE/UMT-0104, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

6. Ford, Bacon & Davis Utah, Inc. August 1981. Engineering Assessment of Inactive Uranium Mill Tailings - New and Old Rifle Sites, Rifle, Colorado. DOE/UMT-0108, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

7. Ford, Bacon & Davis Utah, Inc. August 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Riverton Site, Riverton, Wyoming. DOE/UMT-0106, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

8. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Gunnison Site, Gunnison, Colorado. DOE/UMT-0107, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

9. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Lowman Site, Lowman, Idaho. DOE/UMT-0118, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

10. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Maybell Site, Maybell, Colorado. DOE/UMT-0116, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

11. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Mexican Hat Site, Mexican Hat, Utah. DOE/ UMT-0109, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

12. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Slick Rock Sites, Slick Rock, Colorado. DOE/UMT-0115, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

13. Ford, Bacon & Davis Utah, Inc. September 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Tuba City Site, Tuba City, Arizona. DOE/UMT-0120, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

14. Ford, Bacon & Davis Utah, Inc. October 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Falls City Site, Falls City, Texas. DOE/UMT-0111, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

15. Ford, Bacon & Davis Utah, Inc. October 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Lakeview Site, Lakeview, Oregon. DOE/UMT-0110, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

16. Ford, Bacon & Davis Utah, Inc. October 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Monument Valley Site, Monument Valley, Arizona. DOE/UMT-0117, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

17. Ford, Bacon & Davis Utah, Inc. October 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Philips/United Nuclear Site, Ambrosia Lake, New Mexico. DOE/UMT-0113, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

18. Ford, Bacon & Davis Utah, Inc. October 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Spook Site, Converse County, Wyoming. DOE/UMT-0119, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

19. Ford, Bacon & Davis Utah, Inc. November 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Belfield Site, Belfield, South Dakota. DOE/UMT-0122, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

20. Ford, Bacon & Davis Utah, Inc. November 1981. Engineering Assessment of Inactive Uranium Mill Tailings - Bowman Site, Bowman, South Dakota. DOE/UMT-0121, prepared for the U.S. Department of Energy by Ford, Bacon & Davis Utah, Inc., Salt Lake City, Utah.

21. Douglas, Richard L., and Joseph M. Hans, Jr. August 1975. Gamma Radiation Surveys at Inactive Uranium Mill Sites. ORP/LV-75-5, prepared for the U.S. Environmental Protection Agency, Office of Radiation Programs - Las Vegas Facility, Las Vegas, Nevada.

22. Young, J.K., L.W. Long and J.W. Reis. April 1982. Environmental Factors Affecting Long-Term Stabilization of Radon Suppression Covers for Uranium Mill Tailings. NUREG/CR-2564, prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

23. Pacific Northwest Laboratory. January 1984. Estimated Population Near Uranium Tailings. PNL-4959/UC-70, prepared for the U.S. Environmental Protection Agency by Pacific Northwest Laboratory, Richland, Washington.

24. U.S. EPA. October 1982. Final Environmental Impact Statement for Remedial Action Standards for Inactive Uranium Processing Sites (40CFR192). EPA-520/4/82/013-1, Office of Radiation Programs, EPA, Washington, D.C.

25. U.S. DOE. January 7, 1987. Uranium Mill Tailings Remedial Action Project Ground Water Matrix.

CHAPTER 4

COMPILATION AND ANALYSIS OF GROUNDWATER DATA FOR 14 SITES

4.1 INTRODUCTION

Groundwater quality data for 14 Uranium Mill Tailings Remedial Action (UMTRA) Project sites are analyzed in this chapter. The 14 UMTRA sites are:

Ambrosia Lake, New Mexico
Canonsburg, Pennsylvania
Durango, Colorado
Grand Junction, Colorado
Green River, Utah
Gunnison, Colorado
Lakeview, Oregon
Mexican Hat, Utah
Monument Valley, Arizona
Rifle, Colorado
Riverton, Wyoming
Salt Lake City, Utah
Shiprock, New Mexico
Tuba City, Arizona

This task analyzes the groundwater quality data collected from wells on the sites and from wells surrounding the sites. These data have been compared to the standards given or referenced in Table A of 40 CFR 192.32(a), which are as follows:

Constituent	Maximum Concentration
Arsenic	0.5 mg/l
Barium	1.0 mg/l
Cadmium	0.01 mg/l
Chromium	0.05 mg/l
Gross Alpha Particle Activity (including radium-226 but excluding radon uranium)	15.0 pCi/l
Lead	0.05 mg/l
Mercury	0.002 mg/l
Combined radium-226 and radium-228	5.0 pCi/l
Selenium	0.01 mg/l
Silver	0.05 mg/l

These comparisons are in Table 1 for each of the 14 sites.

In addition to the constituents listed above, six pesticides were also referenced in 40 CFR 192.32 (a). No water quality comparisons were performed for endrin, lindane, methoxychlor, toxaphene, 2,4-D, or 2,4,5, TP. Water samples from the sites were rarely analyzed for these pesticides. These pesticides were undetected in the occasional samples that were analyzed.

Three additional water quality comparisons beyond those in Table A of 40 CFR 192.32(a), but related to leachate from uranium mill tailings, are:

Constituent	Maximum Concentration
Molybdenum	0.10 mg/l
Uranium	30 pCi/l (0.044 mg/l)
Nitrate (nitrogen)	10 mg/l

These comparison are in Table 2 for each of the sites. Also in Table 2 are comparisons to EPA primary and secondary drinking water standards not contained in Table 1. A summary of the water quality data has been prepared for each site. The tabular data are presented after each site summary. The site summaries discuss the key contaminants and their significance of occurrence within the context of the site hydrogeologic setting and local groundwater use.

The fate of the contaminant plume was modeled at 9 of the sites. The results indicate natural reduction of the mobile contaminants (nitrates, chlorides, sulfates, and total dissolved solids) to standards or background levels in 100 years or less at 6 of the 9 sites modeled. The longest period indicated was for the Mexican Hat site where over 500 years will be required for natural flushing of the mobile contaminants. Purging of the attenuated contaminants (uranium, molybdenum, and other metals) typically takes 2 to 3 times as long and only at one site are levels predicted to reach standards or background levels within 100 years. At 6 of the sites it appears that purging of these may be accomplished within 300 years.

4.2 AMBROSIA LAKE, NEW MEXICO - SUMMARY OF WATER QUALITY

The saturated formations at the Ambrosia Lake site include the alluvium, Tres Hermanos Sandstones, Dakota Sandstone and Westwater Canyon Sandstone. Prior to mining and milling activities, it appears that the alluvium and Tres Hermanos-C Sandstone were unsaturated. Their current saturation is believed to be a result of mine water discharges and percolation from tailings slurry water.

The alluvium and Tres Hermanos Sandstone are not currently used as a water supply source. The Westwater Canyon Sandstone is presently a major water supply formation. Contaminated water in the Tres Hermanos-C Sandstone may eventually flow into the Westwater Canyon Sandstone via the Ann Lee Mine shaft or other mine shafts or vents.

Groundwater quality data were analyzed for the alluvium, Tres Hermanos C1 and C2 Sandstone and from beneath saturated uranium mill tailings present on the site. The alluvium data include background, upgradient, cross-gradient, on-site and down gradient samples. The Tres Hermanos-C1 Sandstone data are from only down gradient samples. The Tres Hermanos-C2 Sandstone data are from cross-gradient and down gradient samples.

Levels for arsenic, cadmium, chromium, gross alpha, radium, selenium, and silver exceeded the standards in some samples. Chromium concentrations were higher in on-site and down gradient samples in the tailings, alluvium and Tres Hermanos Sandstones than in background or cross-gradient samples. Twenty four out of 68 analyses for selenium exceeded the limits for the standard; concentrations are highest in the background and upgradient alluvium. Radium concentrations from samples in the on-site tailings and alluvium were substantially higher than in background, upgradient, cross-gradient or down gradient samples. The one upgradient sample analyzed for gross alpha exceeded the standard by more than a factor of 15.

The contaminated water in the alluvium and Tres Hermanos Formation is draining into mine shafts and vents, mixing with groundwater in the Westwater Canyon Sandstone. Modeling indicates that contaminants are dispersed in the Westwater Canyon Sandstone within 400 feet of the mixing zone and that drainage and dilution of the contaminated water will be completed in about 100 years.

TABLE 4-1
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Alluvium	8	1	12	0.18
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	2	---	---	---
		On-Site	Alluvium	18	1	5	0.33
		On-Site	Uranium Mill Tailings	12	---	---	---
		Down gradient	Alluvium	3	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	12	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	7	---	---	---
Barium	1.0	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
		On-Site	Alluvium	7	---	---	---
		On-Site	Uranium Mill Tailings	10	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	8	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	3	---	---	---

TABLE 4-1
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Cadmium	0.01	Background	Alluvium	7	---	---	---
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	2	---	---	---
		On-Site	Alluvium	16	1	6	0.10
		On-Site	Uranium Mill Tailings	12	---	---	---
		Down gradient	Alluvium	3	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	12	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	7	---	---	---
Chromium	0.05	Background	Alluvium	7	---	---	---
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	2	---	---	---
		On-Site	Alluvium	16	2	12	0.20
		On-Site	Uranium Mill Tailings	12	1	8	0.10
		Down gradient	Alluvium	3	1	33	0.17
		Down gradient	Tres Hermanos-C 1 Sandstone	12	1	8	0.21
		Down gradient	Tres Hermanos-C 2 Sandstone	7	2	28	0.11

TABLE 4-1

Site Name: Ambrosia Lake (New Mexico)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2 2/	1	100	251.72
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
		On-Site	Alluvium	1 3/	3/	3/	3/
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	1 3/	3/	3/	3/
		Down gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
Lead	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
		On-Site	Alluvium	7	---	---	---
		On-Site	Uranium Mill Tailings	10	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	8	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	3	---	---	---

TABLE 4-1
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
		On-Site	Alluvium	6	---	---	---
		On-Site	Uranium Mill Tailings	9	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	8	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	3	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	4 4/	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	2 4/	---	---	---
		On-Site	Alluvium	8	7 5/	87	410
		On-Site	Uranium Mill Tailings	10	10 5/	100	240
		Down gradient	Alluvium	1	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	10	2 5/	20	22.0
		Down gradient	Tres Hermanos-C 2 Sandstone	4	1 5/	25	5.6

TABLE 4-1
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Background	Alluvium	8	2	25	0.95
		Upgradient	Alluvium	4	2	50	0.53
		Cross-gradient	Alluvium	2	2	100	0.033
		Cross-gradient	Tres Hermanos-C 2 Sandstone	2	---	---	---
		On-Site	Alluvium	18	6	33	0.147
		On-Site	Uranium Mill Tailings	12	7	58	0.019
		Down gradient	Alluvium	3	1	33	0.127
		Down gradient	Tres Hermanos-C 1 Sandstone	12	4	33	0.225
		Down gradient	Tres Hermanos-C 2 Sandstone	7	---	---	---
Silver	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C 2 Sandstone	1	---	---	---
		On-Site	Alluvium	7	1	14	0.15
		On-Site	Uranium Mill Tailings	10	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C 1 Sandstone	8	---	---	---
		Down gradient	Tres Hermanos-C 2 Sandstone	3	---	---	---

TABLE 4-1
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.
2/ Uranium data available for 1 of 2 samples.
3/ Uranium not analyzed.
4/ Analyses for Ra-226 only.
5/ Ra-226 values. Ra-228 values were all less than the standard.
--- Standard not exceeded.

TABLE 4-2

Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Alluvium	9	---	---	---
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	7	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	19	4	21	489
		On-Site	Uranium Mill Tailings	11	---	---	---
		Down gradient	Alluvium	4	2	50	300
		Down gradient	Tres Hermanos-C1 Sandstone	13	2	15	270
		Down gradient	Tres Hermanos-C2 Sandstone	8	---	---	---
Copper	1.0	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	1	---	---	---
		On-Site	Alluvium	7	---	---	---
		On-Site	Uranium Mill Tailings	10	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C1 Sandstone	8	---	---	---
		Down gradient	Tres Hermanos-C2 Sandstone	3	---	---	---

TABLE 4-2

Site Name: Ambrosia Lake (New Mexico)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Fluoride	1.4	Background	Alluvium	7	---	---	---
		Upgradient	Alluvium	4	3	75	2.2
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	12	2	16	15.0
		On-Site	Uranium Mill Tailings	11	10	90	21.0
		Down gradient	Alluvium	3	1	33	2.2
		Down gradient	Tres Hermanos-C1 Sandstone	12	6	50	2.1
		Down gradient	Tres Hermanos-C2 Sandstone	7	---	---	---
Hydrogen Sulfide	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	1	---	---	---
		On-Site	Alluvium	1	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
		Down gradient	Tres Hermanos-C1 Sandstone	1	---	---	---
		Down gradient	Tres Hermanos-C2 Sandstone	1	---	---	---

TABLE 4-2
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Background	Alluvium	7	1	14	0.61
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	15	4	26	5.49
		On-Site	Uranium Mill Tailings	11	3	27	1.46
		Down gradient	Alluvium	3	2	66	4.13
		Down gradient	Tres Hermanos-C1 Sandstone	12	---	---	---
		Down gradient	Tres Hermanos-C2 Sandstone	7	3	42	28.8
Manganese	0.05	Background	Alluvium	7	6	85	0.17
		Upgradient	Alluvium	2	1	50	0.07
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	15	14	93	0.68
		On-Site	Uranium Mill Tailings	11	---	---	---
		Down gradient	Alluvium	3	2	66	4.23
		Down gradient	Tres Hermanos-C1 Sandstone	11	6	54	0.13
		Down gradient	Tres Hermanos-C2 Sandstone	7	6	85	1.82

TABLE 4-2
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Molybdenum	0.10	Background	Alluvium	8	7	88	0.22
		Upgradient	Alluvium	4	3	75	1.87
		Cross-gradient	Alluvium	2	2	100	0.50
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	2	100	0.17
		On-Site	Alluvium	18	18	100	225
		On-Site	Uranium Mill Tailings	12	12	100	250
		Down gradient	Alluvium	3	3	100	3.17
		Down gradient	Tres Hermanos-C1 Sandstone	12	12	100	10.3
		Down gradient	Tres Hermanos-C2 Sandstone	7	6	86	0.35
Nitrate 2/	44	Background	Alluvium	8	2	25	49.0
		Upgradient	Alluvium	4	1	25	55.0
		Cross-gradient	Alluvium	6	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	16	1	6	150
		On-Site	Uranium Mill Tailings	11	5	45	4900
		Down gradient	Alluvium	4	2	50	140
		Down gradient	Tres Hermanos-C1 Sandstone	13	7	53	400
		Down gradient	Tres Hermanos-C2 Sandstone	8	---	---	---

TABLE 4-2
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Background	Alluvium	9	---	---	---
		Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	7	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	2	100	12.2
		On-Site	Alluvium	18	3	16	9.97
		On-Site	Uranium Mill Tailings	11	10	90	10.13
		Down gradient	Alluvium	4	1	25	11.18
		Down gradient	Tres Hermanos-C1 Sandstone	13	3	23	12.46
		Down gradient	Tres Hermanos-C2 Sandstone	8	1	12	11.92
Sulfate	250	Background	Alluvium	9	9	100	4940
		Upgradient	Alluvium	4	4	100	2750
		Cross-gradient	Alluvium	7	7	100	2440
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	2	100	633
		On-Site	Alluvium	19	19	100	10,300
		On-Site	Uranium Mill Tailings	12	12	100	11,000
		Down gradient	Alluvium	4	4	100	4440
		Down gradient	Tres Hermanos-C1 Sandstone	13	11	84	4010
		Down gradient	Tres Hermanos-C2 Sandstone	8	8	100	3970

TABLE 4-2
Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	1	100	0.10
		Cross-gradient	Tres Hermanos-C2 Sandstone	1	1	100	0.10
		On-Site	Alluvium	6	6	100	0.10
		On-Site	Uranium Mill Tailings	9	9	100	0.10
		Down gradient	Alluvium	2	2	100	0.10
		Down gradient	Tres Hermanos-C1 Sandstone	7	7	100	0.10
		Down gradient	Tres Hermanos-C2 Sandstone	3	3	100	0.10
Total Solids	500	Background	Alluvium	8	8	100	8080
		Upgradient	Alluvium	4	4	100	4400
		Cross-gradient	Alluvium	2	2	100	4060
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	2	100	1880
		On-Site	Alluvium	17	17	100	20,900
		On-Site	Uranium Mill Tailings	10	10	100	25,800
		Down gradient	Alluvium	3	3	100	7250
		Down gradient	Tres Hermanos-C1 Sandstone	12	12	100	7190
		Down gradient	Tres Hermanos-C2 Sandstone	7	7	100	6490

TABLE 4-2

Site Name: Ambrosia Lake (New Mexico)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Alluvium	8	3	37	1.26
		Upgradient	Alluvium	3	3	100	3.31
		Cross-gradient	Alluvium	2	2	100	5.34
		Cross-gradient	Tres Hermanos-C2 Sandstone	2	---	---	---
		On-Site	Alluvium	17	17	100	14.70
		On-Site	Uranium Mill Tailings	10	10	100	10.70
		Down gradient	Alluvium	3	2	66	2.80
		Down gradient	Tres Hermanos-C1 Sandstone	11	8	72	11.80
		Down gradient	Tres Hermanos-C2 Sandstone	7	2	29	1.25
Zinc	5.0	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Tres Hermanos-C2 Sandstone	1	---	---	---
		On-Site	Alluvium	6	---	---	---
		On-Site	Uranium Mill Tailings	9	---	---	---
		Down gradient	Alluvium	2	---	---	---
		Down gradient	Tres Hermanos-C1 Sandstone	7	---	---	---
		Down gradient	Tres Hermanos-C2 Sandstone	3	---	---	---

TABLE 4-2

Site Name: Ambrosia Lake (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.3 CANONSBURG, PENNSYLVANIA - SUMMARY OF WATER QUALITY

The collection of hydrogeological and groundwater quality data for the Canonsburg site began in 1979. However, due to the potential for high levels of radioactive contamination, the location of wells was restricted. Also, aquifer pump tests were prohibited due to the potential for withdrawing radioactively contaminated groundwater. In 1982, additional drilling was conducted to further characterize the groundwater regime. The 1982 effort concluded that significant data gaps still existed regarding the hydrogeological information.

From December 1982 through March 1983, a third field effort was undertaken to characterize the site hydrogeology. During this effort, monitoring wells were constructed on-site in the overburden and in the bedrock. Off-site monitoring wells were constructed south of the site. Aquifer data from the unconsolidated material and the bedrock were collected. Surface water data from Chartiers Creek were collected to determine the hydrological relationship between the groundwater and Chartiers Creek.

The amount of groundwater quality data for the period 1979 to March 1983 is minimal. The value of these data may be limited with regards to site groundwater quality characterization. This is primarily due to the early drilling restrictions which applied to most of the site. The data that are available for this period of time show that several constituents in the groundwater beneath the site, and in the vicinity of the site, exceeded existing standards. Some on-site groundwater samples exceeded existing standards for arsenic, chloride, iron, pH, selenium and sulfate. Nitrate, pH and selenium exceeded the existing standards in some off-site groundwater samples.

Remedial action at the process site is complete. The data evaluated and presented in the following tables represent post-closure groundwater quality data. These data are from two quarterly post-remedial sampling efforts conducted between 08/05/86 and 11/06/86. Presently, seven wells (four on-site and three off-site) comprise the primary monitoring network.

Two saturated zones are presently monitored. These are the unconsolidated soils and shallow shale and limestone.

Recharge is from the east and discharge occurs to Chartiers Creek to the north, west, and south. Some groundwater may flow beneath Chartiers Creek in the shallow shale/limestone. Approximately 12 wells have been identified within a one-mile radius on the site. Most of these wells have been abandoned , with the remaining wells receiving limited use, primarily for watering gardens.

Monitoring data from the site include upgradient, cross-gradient and down gradient samples. Background data are not available. Table 1 shows that none of the constituents exceeded standards. However, this must be evaluated in terms of the data time interval (six months) and that the data are from post-closure monitoring.

Most of the groundwater from the contaminated alluvium discharges to Chartier Creek within a few hundred feet of the site; some may underflow the creek in shallow bedrock. Modeling indicates that discharges of the mobile contaminants (NO_3, Cl, SO_4, TDS) will be within standards within 60 years and discharges of the attenuated contaminants (U, Mo, metals) in excess of standards will continue for two to three times as long.

TABLE 4-3
Site Name: Canonsburg (Pennsylvania)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Barium	1.0	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Cadmium	0.01	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Chromium	0.05	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	---	---	---

TABLE 4-3
Site Name: Canonsburg (Pennsylvania)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Lead	0.05	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Mercury	0.002	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Upgradient	Alluvium	4	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Selenium	0.01	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Silver	0.05	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-4
Site Name: Canonsburg (Pennsylvania)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Copper	1.0	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Fluoride	1.4	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---
Hydrogen Sulfide	0.05	Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	---	---	---

TABLE 4-4
Site Name: Canonsburg (Pennsylvania)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Upgradient	Alluvium	5	4	80	14.5
		Cross-gradient	Alluvium	2	2	100	1.42
		On-Site	Alluvium	8	2	25	14.7
Manganese	0.05	Upgradient	Alluvium	5	5	100	3.32
		Cross-gradient	Alluvium	2	2	100	11.5
		On-Site	Alluvium	8	8	100	9.41
Molybdenum	0.10	Upgradient	Alluvium	5	5	100	0.27
		Cross-gradient	Alluvium	2	2	100	0.18
		On-Site	Alluvium	8	8	100	0.20
Nitrate 2/	44	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---

TABLE 4-4
Site Name: Canonsburg (Pennsylvania)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Upgradient	Alluvium	5	3	60	5.60
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	6	75	6.34
Sulfate	250	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	8	100	626
Sulfide	0.05	Upgradient	Alluvium	4	4	100	0.10
		Cross-gradient	Alluvium	2	2	100	0.10
		On-Site	Alluvium	8	8	100	0.10
Total Solids	500	Upgradient	Alluvium	5	2	40	802
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	8	100	1310

TABLE 4-4

Site Name: Canonsburg (Pennsylvania)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 08/05/86 to 11/06/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	2	100	0.0221
		On-Site	Alluvium	8	2	25	0.0492
Zinc	5.0	Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	8	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.4 DURANGO, COLORADO - SUMMARY OF WATER QUALITY

The analysis of groundwater quality at the Durango site involved upgradient and down gradient data. No background or preprocessing era data were available. There are no current groundwater users within two miles down gradient of the site.

Levels of arsenic, chromium and selenium exceeded the standards in some samples. Selenium exceeded the standard in one upgradient sample by a factor of 35 and in nearly 80 percent of the down gradient samples by factors as high as 190. Arsenic and chromium exceeded the standards only in the down gradient samples, arsenic by a factor of 16 and chromium by a factor of two.

The contaminated groundwater discharges to the Animas River within 100 to 500 feet of the piles and ponds. Modeling indicates that the mobile contaminants will be flushed from the alluvial aquifer in approximately 5 years and from the Menefee Formation in 40 years. Flushing of the attenuated contaminants from the alluvial aquifer will take 15 years and from the Menefee Formation about 40 years.

TABLE 4-5

Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Upgradient	Gravel or sandy gravel, poorly graded	5	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	6	28	0.83
		Down gradient	Silty Sand or Silty gravelly sand	6	1	16	0.10
		Down gradient	Shale	22	---	---	---
Barium	1.0	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	5	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	1	---	---	---
		Down gradient	Shale	5	---	---	---

TABLE 4-5
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Cadmium	0.01	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---
Chromium	0.05	Upgradient	Gravel or sandy gravel, poorly graded	4	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	6	1	16	0.10
		Down gradient	Shale	20	---	---	---

TABLE 4-5
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---
Lead	0.05	Upgradient	Gravel or sandy gravel, poorly graded	4	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	6	---	---	---
		Down gradient	Shale	20	---	---	---

TABLE 4-5
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Upgradient	Gravel or sandy gravel, poorly graded	2 2/	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	12 2/	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	2 2/	---	---	---
		Down gradient	Shale	10 2/	---	---	---

TABLE 4-5
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Upgradient	Gravel or sandy gravel, poorly graded	5	1	20	0.36
		Down gradient	Gravel or sandy gravel, poorly graded	21	17	80	1.20
		Down gradient	Silty Sand or Silty gravelly sand	6	4	66	1.90
		Down gradient	Shale	22	18	81	1.60
Silver	0.05	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty Sand or Silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Analyses for Ra-226 only.
--- Standard not exceeded.

TABLE 4-6
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Upgradient	Gravel or sandy gravel, poorly graded	5	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	9	42	1100
		Down gradient	Silty sand or silty gravelly sand	6	4	66	390
		Down gradient	Shale	22	12	54	1100
Copper	1.0	Upgradient	Gravel or sandy gravel, poorly graded	4	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	---	---	---
		Down gradient	Silty sand or silty gravelly sand	6	---	---	---
		Down gradient	Shale	20	---	---	---

TABLE 4-6
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Fluoride	1.4	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty sand or silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---
Hydrogen Sulfide	0.05	Upgradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Silty sand or silty gravelly sand	1	---	---	---
		Down gradient	Shale	1	---	---	---

TABLE 4-6
Site Name: Durango (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Upgradient	Gravel or sandy gravel, poorly graded	5	1	20	0.15
		Down gradient	Gravel or sandy gravel, poorly graded	21	18	86	6.20
		Down gradient	Silty sand or silty gravelly sand	6	6	100	2.40
		Down gradient	Shale	22	22	100	4.07
Zinc	5.0	Upgradient	Gravel of sandy gravel, poorly graded	4	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	21	---	---	---
		Down gradient	Silty sand or silty gravelly sand	6	---	---	---
		Down gradient	Shale	20	---	---	---

TABLE 4-6

Site Name: Durango (Colorado)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 09/01/82 to 11/13/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.

2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.

3/ pH reported in standard units.

4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.

--- Standard not exceeded.

4.5 GRAND JUNCTION, COLORADO - SUMMARY OF WATER QUALITY

The Grand Junction process site lies in an industrial area along the northern bank of the Colorado River. Sedimentary units in and around the site are, in ascending order, the Dakota Sandstone, the Mancos Shale, and alluvium. Two drillings programs were conducted; the first phase was to determine the source of contamination to the alluvium; the second considered background and down gradient hydraulics and water quality in the alluvium and underlying beds of the Mancos Shale and Dakota Sandstone.

Groundwater sampling indicated that limits of concentrations for arsenic, cadmium, radium, chromium, selenium, and gross alpha were exceeded. Arsenic and cadmium concentrations were higher in on-site (alluvium and tailings) samples than in other localities sampled in the alluvium. One of 23 upgradient analyses for chromium and twelve out of 33 on-site analysis for selenium exceeded the limit for the standard. Four of 9 down gradient samples exceeded the standard for gross alpha. Eight of 18 on-site analyses for radium as well as three of 30 down gradient radium samples, exceeded the limit for the standard.

Groundwater flow discharges in the Colorado River with some possibly contributing to recharge of the Dakota Sandstone at a subcrop 1/2 mile west of the site. Based on modeling results, discharge and dispersal of the mobile contaminants is expected within 50 to 60 years; uranium and ammonia may persist in the alluvial aquifers for 150 to 300 years.

TABLE 4-7
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	32	5	15	0.18
		On-Site	Uranium Mill Tailings	1	1	100	1.68
		Down gradient	Alluvium	39	1	2	0.11
Barium	1.0	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	30	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	---	---	---
Cadmium	0.01	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	22	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	24	6	25	0.42
		On-Site	Uranium Mill Tailings	1	1	100	0.035
		Down gradient	Alluvium	31	---	---	---

TABLE 4-7
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chromium	0.05	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	1	4	0.07
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	31	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	---	---	---
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Alluvium	2 2/	2/	2/	2/
		Upgradient	Alluvium	4 2/	2/	2/	2/
		Cross-gradient	Alluvium	3 2/	2/	2/	2/
		On-Site	Alluvium	4 3/	3	100	129.20
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	9 4/	4	100	187.40
Lead	0.05	Background	Alluvium	4	---	---	---
		Upgradient	Alluvium	13	---	---	---
		Cross-gradient	Alluvium	6	---	---	---
		On-Site	Alluvium	16	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	22	---	---	---

TABLE 4-7
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	22	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	24	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	31	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Alluvium	5	---	---	---
		Upgradient	Alluvium	18	---	---	---
		Cross-gradient	Alluvium	7	---	---	---
		On-Site	Alluvium	18 5/	8 6/	44	29.0
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	30 5/	3 6/	10	18.0
Selenium	0.01	Background	Alluvium	6	1	16	0.014
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	32	11	34	0.24
		On-Site	Uranium Mill Tailings	1	1	100	1.69
		Down gradient	Alluvium	39	1	2	0.012

TABLE 4-7
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Silver	0.05	Background	Alluvium	4	---	---	---
		Upgradient	Alluvium	13	---	---	---
		Cross-gradient	Alluvium	6	---	---	---
		On-Site	Alluvium	16	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	22	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Uranium not analyzed.
3/ Uranium not analyzed for one sample.
4/ Uranium analyzed in 4 of 9 samples.
5/ Ra-226 only.
6/ Values for Ra-226 only. Ra-228 values were all less than the standard.
--- Standard not exceeded.

TABLE 4-8

Site Name: Grand Junction (Colorado)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Alluvium	52	39	75	473
		Upgradient	Alluvium	23	15	65	783
		Cross-gradient	Alluvium	9	9	100	1250
		On-Site	Alluvium	32	32	100	1030
		On-Site	Uranium Mill Tailings	1	1	100	2990
		Down gradient	Alluvium	40	40	100	1270
Copper	1.0	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	32	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	---	---	---
Fluoride	1.4	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	22	2	9	1.60
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	24	20	83	4.90
		On-Site	Uranium Mill Tailings	1	1	100	16.0
		Down gradient	Alluvium	31	8	25	3.70

TABLE 4-8
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Hydrogen Sulfide	0.05	Background	Alluvium	4	4	100	1.20
		Upgradient	Alluvium	13	13	100	0.20
		Cross-gradient	Alluvium	6	6	100	0.36
		On-Site	Alluvium	12	12	100	0.20
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	18	18	100	0.20
Iron	0.30	Background	Alluvium	6	4	66	1.20
		Upgradient	Alluvium	23	10	43	3.04
		Cross-gradient	Alluvium	9	8	88	5.70
		On-Site	Alluvium	32	22	68	12.00
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	26	66	16.00
Manganese	0.05	Background	Alluvium	6	6	100	8.74
		Upgradient	Alluvium	23	23	100	2.91
		Cross-gradient	Alluvium	9	9	100	4.60
		On-Site	Alluvium	32	32	10	10.00
		On-Site	Uranium Mill Tailings	1	1	100	0.33
		Down gradient	Alluvium	39	39	100	334

TABLE 4-8
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Molybdenum	0.10	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	6	26	0.15
		Cross-gradient	Alluvium	9	5	56	0.14
		On-Site	Alluvium	32	24	75	0.53
		On-Site	Uranium Mill Tailings	1	1	100	8.65
		Down gradient	Alluvium	39	17	44	0.47
Nitrate 2/	44	Background	Alluvium	8	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	28	1	3	50.0
		On-Site	Uranium Mill Tailings	1	1	100	1100
		Down gradient	Alluvium	35	---	---	---
pH 3/	6.5 to 8.5	Background	Alluvium	52	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	32	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	---	---	---

TABLE 4-8
Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfate	250	Background	Alluvium	52	52	100	4170
		Upgradient	Alluvium	23	20	86	3410
		Cross-gradient	Alluvium	9	9	100	4000
		On-Site	Alluvium	32	32	100	4900
		On-Site	Uranium Mill Tailings	1	1	100	6110
		Down gradient	Alluvium	39	39	100	4500
Sulfide	0.05	Background	Alluvium	2	2	100	0.10
		Upgradient	Alluvium	9	9	100	0.10
		Cross-gradient	Alluvium	3	3	100	0.10
		On-Site	Alluvium	8	8	100	0.10
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium				
Total Solids	500	Background	Alluvium	52	52	100	7220
		Upgradient	Alluvium	23	22	95	6930
		Cross-gradient	Alluvium	9	9	100	8530
		On-Site	Alluvium	32	32	100	8100
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	39	100	12,134

TABLE 4-8

Site Name: Grand Junction (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 09/23/77 to 09/11/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	3	3	100	0.185
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	4	4	100	0.445
Zinc	5.0	Background	Alluvium	6	---	---	---
		Upgradient	Alluvium	23	---	---	---
		Cross-gradient	Alluvium	9	---	---	---
		On-Site	Alluvium	32	---	---	---
		On-Site	Uranium Mill Tailings	1	---	---	---
		Down gradient	Alluvium	39	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in Standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.6 GUNNISON, COLORADO - SUMMARY OF WATER QUALITY

The site is immediately south of the City of Gunnison, Colorado; and is between the Gunnison River and Tomichi Creek. The site overlies the principal aquifer of the area. More than 75 wells, most of them domestic wells less than 30 feet deep, are within one mile of the site. The City of Gunnison operates a municipal well field approximately one mile north (upgradient) of the site.

The quality of background water is generally potable with some exceptions. High concentrations of iron are found in the alluvial aquifer. Hydrogen sulfide is found in a reducing zone along the Gunnison River.

The groundwater analyses for the Gunnison site included background, upgradient, cross-gradient, on-site and down gradient data. All data are from wells in the alluvium. Barium was the only constituent which exceeded the standards in the background samples. One of 21 background samples exceeded the barium standard. No constituents exceeded the standards in the upgradient or cross-gradient wells.

Arsenic and gross alpha exceeded the standards in the on-site samples. The arsenic standard was exceeded in 3 out of 7 samples, with a maximum value exceeding the standard by a factor of more than four. One gross alpha sample was analyzed and it exceeded the standard by a factor of more than ten.

The down gradient samples contained the greatest number of contaminants. In these samples the standards were exceeded for arsenic, cadmium, gross alpha, mercury and selenium. Two out of 123 samples exceeded the arsenic standard by a factor of less than two. The maximum values for both cadmium and gross alpha exceeded standards by more than a factor of three. The one mercury sample analyzed exceeded the standard by a factor of 14,300. Nine out of 123 samples analyzed for selenium exceeded the standard. The maximum value for selenium was more than a factor of 10 greater than the standard.

The contaminants disperse in the alluvial aquifer which discharges at the confluence of the Gunnison River and Tomichi Creek, 2 miles from the site. Modeling indicates that discharges of the mobile contaminants will reach background standards in approximately 75 years. The discharge period of the attenuated contaminants was not modeled.

TABLE 4-9
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	3	42	0.23
		Down gradient	Alluvium	123	2	2	0.07
Barium	1.0	Background	Alluvium	21	1	5	1.2
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	123	---	---	---
Cadmium	0.01	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	123	7	6	0.034
Chromium	0.05	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	122	---	---	---

TABLE 4-9
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Alluvium	5	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	1	100	151.12
		Down gradient	Alluvium	11	4	36	49.98
Lead	0.05	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	121	---	---	---
Mercury	0.002	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	---	---	---
		Down gradient	Alluvium	1	1	100	28.6
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Alluvium	6 2/	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	4 2/	---	---	---
		Down gradient	Alluvium	23	---	---	---

TABLE 4-9

Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	123	9	7	0.103
Silver	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	---	---	---
		Down gradient	Alluvium	1	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Analyses for Ra-226 only.
--- Standard not exceeded.

TABLE 4-10
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	123	---	---	---
Copper	1.0	Background	Alluvium	15	---	---	---
		Upgradient	Alluvium	3	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	5	---	---	---
		Down gradient	Alluvium	81	---	---	---
Fluoride	1.4	Background	Alluvium	15	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	4	---	---	---
		Down gradient	Alluvium	64	4	6	2.60
Hydrogen Sulfide	0.05	Background	Alluvium	1	---	---	---
		Upgradient	Alluvium	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
Iron	0.30	Background	Alluvium	21	10	47	5.63
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	2	100	1.90
		On-Site	Alluvium	7	7	100	37.80
		Down gradient	Alluvium	122	69	56	101

TABLE 4-10
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Manganese	0.05	Background	Alluvium	15	11	73	4.69
		Upgradient	Alluvium	5	2	40	0.29
		Cross-gradient	Alluvium	2	2	100	2.09
		On-Site	Alluvium	6	6	100	34.30
		Down gradient	Alluvium	101	85	84	77.00
Molybdenum	0.10	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	2	29	0.18
		Down gradient	Alluvium	123	---	---	---
Nitrate 2/	44	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	---	---	---
		Down gradient	Alluvium	123	6	4	110
pH 3/	6.5 to 8.5	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	1	50	6.08
		On-Site	Alluvium	7	7	100	5.66
		Down gradient	Alluvium	117	66	56	5.08/12.32
Sulfate	250	Background	Alluvium	21	---	---	---
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	7	100	1480
		Down gradient	Alluvium	122	62	50	1820

TABLE 4-10
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Alluvium	6	6	100	0.10
		Upgradient	Alluvium	2	2	100	0.10
		Cross-gradient	Alluvium	1	1	100	0.10
		On-Site	Alluvium	2	2	100	0.10
		Down gradient	Alluvium	43	43	100	1.00
Total Solids	500	Background	Alluvium	21	1	4	713
		Upgradient	Alluvium	5	---	---	---
		Cross-gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	7	7	100	2510
		Down gradient	Alluvium	122	78	63	3160
Uranium 4/	0.044	Background	Alluvium	15	---	---	---
		Upgradient	Alluvium	2	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	5	2	40	0.1160
		Down gradient	Alluvium	78	29	37	1.20
Zinc	5.0	Background	Alluvium	15	---	---	---
		Upgradient	Alluvium	3	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		On-Site	Alluvium	5	---	---	---
		Down gradient	Alluvium	82	---	---	---

TABLE 4-10
Site Name: Gunnison (Colorado)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 10/12/83 to 06/20/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

TABLE 4-11
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Cadmium	0.01	Background	Sand or gravelly sand, poorly graded	25	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	18	1	5	0.04
		Down gradient	Sand or gravelly sand, poorly graded	55	3	5	0.31
Chromium	0.05	Background	Sand or gravelly sand, poorly graded	12	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	6	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	15	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	46	3	6	0.08

TABLE 4-11
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Sand or gravelly sand, poorly graded	1	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	1	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	1	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	1	1	100	23.32
Lead	0.05	Background	Sand or gravelly sand, poorly graded	9	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	4	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	14	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	35	---	---	---

TABLE 4-11
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Background	Sand or gravelly sand, poorly graded	6	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	2	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	8	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	20	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Sand or gravelly sand, poorly graded	8	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	4	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	7	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	30	1	3	76.0

TABLE 4-11
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Background	Sand or gravelly sand, poorly graded	10	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	4	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	16	3	18	0.243
		Down gradient	Sand or gravelly sand, poorly graded	38	---	---	---
Silver	0.05	Background	Sand or gravelly sand, poorly graded	5	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	2	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	7	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	19	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Sand or gravelly sand, poorly graded	25	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	18	6	33	3400
		Down gradient	Sand or gravelly sand, poorly graded	57	23	40	2400
Copper	1.0	Background	Sand or gravelly sand, poorly graded	10	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	4	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	15	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	36	---	---	---

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Fluoride	1.4	Background	Sand or gravelly sand, poorly graded	25	10	40	4.7
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	18	8	44	6.27
		Down gradient	Sand or gravelly sand, poorly graded	57	45	78	8.8
Hydrogen Sulfide	0.05	Background	Sand or gravelly sand, poorly graded	1	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	1	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	1	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	1	---	---	---

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Background	Sand or gravelly sand, poorly graded	25	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	19	6	31	27.0
		Down gradient	Sand or gravelly sand, poorly graded	57	12	21	9.14
Manganese	0.05	Background	Sand or gravelly sand, poorly graded	24	9	37	0.26
		Cross-gradient	Sand or gravelly sand, poorly graded	7	7	100	8.30
		On-Site	Sand or gravelly sand, poorly graded	17	12	70	25.0
		Down gradient	Sand or gravelly sand, poorly graded	54	49	90	24.7

TABLE 4-12

Site Name: Lakeview (Oregon)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Molybdenum	0.10	Background	Sand or gravelly sand, poorly graded	6	1	16	0.11
		Cross-gradient	Sand or gravelly sand, poorly graded	2	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	9	1	11	0.32
		Down gradient	Sand or gravelly sand, poorly graded	27	3	11	0.44
Nitrate 2/	44	Background	Sand or gravelly sand, poorly graded	25	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	18	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	57	---	---	---

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Background	Sand or gravelly sand, poorly graded	25	4	16	6.02/8.90
		Cross-gradient	Sand or gravelly sand, poorly graded	7	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	18	3	16	5.70
		Down gradient	Sand or gravelly sand, poorly graded	60	9	15	5.58/9.30
Sulfate	250	Background	Sand or gravelly sand, poorly graded	25	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	7	4	57	650
		On-Site	Sand or gravelly sand, poorly graded	18	8	44	7300
		Down gradient	Sand or gravelly sand, poorly graded	57	35	61	4700

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Sand or gravelly sand, poorly graded	1	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	1	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	1	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	1	---	---	---
Total Solids	500	Background	Sand or gravelly sand, poorly graded	25	11	43	992
		Cross-gradient	Sand or gravelly sand, poorly graded	7	4	57	1232
		On-Site	Sand or gravelly sand, poorly graded	18	10	55	13,836
		Down gradient	Sand or gravelly sand, poorly graded	57	51	89	12,006

TABLE 4-12
Site Name: Lakeview (Oregon)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Sand or gravelly sand, poorly graded	7	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	4	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	9	1	11	0.10
		Down gradient	Sand or gravelly sand, poorly graded	30	---	---	---
Zinc	5.0	Background	Sand or gravelly sand, poorly graded	11	---	---	---
		Cross-gradient	Sand or gravelly sand, poorly graded	6	---	---	---
		On-Site	Sand or gravelly sand, poorly graded	14	---	---	---
		Down gradient	Sand or gravelly sand, poorly graded	46	---	---	---

TABLE 4-12

Site Name: Lakeview (Oregon)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 08/17/82 to 10/02/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.

2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.

3/ pH reported in standard units.

4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.

--- Standard not exceeded.

4.8 MEXICAN HAT, UTAH - SUMMARY OF WATER QUALITY

The Mexican Hat tailings site is in southeast Utah, approximately one mile south of Mexican Hat, Utah and the San Juan River. Sampling of monitor wells indicate that the tailings have contaminated approximately 80 million gallons of groundwater. Seepage of contaminants into Gypsum Wash (the major surface drainage area of the site) and subsequent contamination of the San Juan River are of major concern. Background water quality is unsuitable for most uses; currently there are no groundwater withdrawals within the site.

Of the standards contained in or referenced in 40 CFR 192.32(a), the limits for chromium, gross alpha, mercury, radium and selenium were exceeded for some samples. Chromium concentrations were higher in background samples in the Rico Formation than in down gradient samples. Two out of 15 background analyses for radium and one out of 15 background analyses for selenium exceeded the limit for the standard. Two out of 14 background samples exceeded the standard for gross alpha. One out of 2 down gradient analyses for mercury exceeded the limit for the standard.

The contaminated groundwater appears to occur in perched zones beneath and adjacent to the site. Because of the low rate of movement of the perched water, over 500 years will be required to flush the mobile contaminants from the groundwater.

TABLE 4-13

Site Name: Mexican Hat (Utah)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 04/10/85 to 11/01/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Rico	15	---	---	---
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	---	---	---
		Down gradient	Siltstone	1	---	---	---
Barium	1.0	Background	Rico	15	---	---	---
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	---	---	---
		Down gradient	Siltstone	1	---	---	---
Cadmium	0.01	Background	Rico	15	---	---	---
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	---	---	---
		Down gradient	Siltstone	1	---	---	---
Chromium	0.05	Background	Rico	15	5	33	0.70
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	1	50	0.21
		Down gradient	Siltstone	1	1	100	0.06
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Rico	14	2	14	25.184
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	1	---	---	---
		Down gradient	Siltstone	1	---	---	---

TABLE 4-14
Site Name: Mexican Hat (Utah)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 04/10/85 to 11/01/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Manganese	0.05	Background	Rico	15	3	20	0.06
		On-Site	Siltstone	1	1	100	0.38
		Down gradient	Rico	2	1	50	0.06
		Down gradient	Siltstone	1	1	100	0.15
Molybdenum	0.10	Background	Rico	15	6	40	0.20
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	---	---	---
		Down gradient	Siltstone	1	1	100	0.10
Nitrate 2/	44	Background	Rico	15	---	---	---
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	2	100	80.0
		Down gradient	Siltstone	1	---	---	---
pH 3/	6.5 to 8.5	Background	Rico	15	1	6	10.24
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	1	50	12.28
		Down gradient	Siltstone	1	---	---	---
Sulfate	250	Background	Rico	15	15	100	4090
		On-Site	Siltstone	1	1	100	3170
		Down gradient	Rico	2	2	100	722
		Down gradient	Siltstone	1	1	100	947

TABLE 4-14

Site Name: Mexican Hat (Utah)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 04/10/85 to 11/01/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Rico	15	15	100	0.10
		On-Site	Siltstone	1	1	100	0.10
		Down gradient	Rico	2	2	100	0.10
		Down gradient	Siltstone	1	---	---	---
Total Solids	500	Background	Rico	15	15	100	6550
		On-Site	Siltstone	1	1	100	1960
		Down gradient	Rico	2	2	100	4250
		Down gradient	Siltstone	1	1	100	1870
Uranium 4/	0.044	Background	Rico	15	2	13	0.0512
		On-Site	Siltstone	1	1	100	0.602
		Down gradient	Rico	2	---	---	---
		Down gradient	Siltstone	1	---	---	0.0334
Zinc	5.0	Background	Rico	15	---	---	---
		On-Site	Siltstone	1	---	---	---
		Down gradient	Rico	2	---	---	---
		Down gradient	Rico	1	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.

2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.

3/ pH reported in standard units.

4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.

--- Standard not exceeded.

4.9 MONUMENT VALLEY, ARIZONA - SUMMARY OF WATER QUALITY

Major hydrostratigraphic units at the Monument Valley site are alluvium and dune sand, the Shinarump Member of the Chinle Formation, the Moenkopi Formation, and the DeChelly Sandstone Member of the Cutler Formation. The alluvium, Shinarump and the DeChelly Sandstone are aquifers. The Moenkopi is an aquitard which separates the Shinarump from the underlying DeChelly Sandstone.

The background water quality in all three of the aquifers is good. Only the alluvial aquifer has been appreciably affected by the tailings. The alluvial groundwater is unconfined and ranges from approximately two feet to 45 feet below the surface in the vicinity of the tailings.

Groundwater use near the site consists of two upgradient alluvial wells which are used by local residents. Three production wells are located on and down gradient of the site. The production wells supplied water for the former milling operations but are not presently used. Two seeps east of the tailings site are discharges of alluvial groundwater and are used for watering livestock. Sampling of these wells and seeps has not revealed the presence of any contamination from the tailings.

Chromium exceeded the standard in some samples from all three down gradient aquifers. The down gradient alluvium had the highest value for chromium, as well as, the highest percentage of samples exceeding the standard.

The gross alpha standard was exceeded in background samples of the Shinarump Formation and the down gradient alluvium and DeChelly Formation samples. The highest values obtained were from the down gradient alluvium, in which the maximum value exceeded the standard by more than a factor of three.

One of nine radium background samples from the Shinarump Formation exceeded the standard. This sample exceeded the standard by a factor of less than two.

The contaminated groundwater is in an unconfined aquifer with no nearby discharge point. Modeling indicates that the mobile contaminant plume will dissipate within the aquifer in approximately 120 years.

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Barium	1.0	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	9	---	---	---
		Background	DeChelly member of the Cutler Formation	7	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	34	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	12	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	4	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Cadmium	0.01	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chromium	0.05	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	12	27	0.09
		Down gradient	Shinarump member of the Chinle Formation	15	1	6	0.07
		Down gradient	DeChelly member of the Cutler Formation	8	2	25	0.07

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	1	10	17.104
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	7	15	45.968
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	1	12	16.372

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Lead	0.05	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	9	---	---	---
		Background	DeChelly member of the Cutler Formation	7	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	34	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	12	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	4	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	9	1	11	8.8
		Background	DeChelly member of the Cutler Formation	7	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	34	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	12	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	3	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-15
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Silver	0.05	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	9	---	---	---
		Background	DeChelly member of the Cutler Formation	7	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	34	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	12	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	4	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uraniuma and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Hydrogen Sulfide	0.05	Background	Alluvium	1	---	---	---
		Background	Shinarump member of the Chinle Formation	1	---	---	---
		Background	DeChelly member of the Cutler Formation	1	---	---	---
		Cross-gradient	Alluvium	1	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	1	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	1	---	---	---
		On-Site	DeChelly member of the Cutler Formation	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	1	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	1	---	---	---

TABLE 4-16

Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	1	10	0.33
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	1	6	0.31
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Manganese	0.05	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	7	70	0.10
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	2	50	0.09
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	3	50	0.21
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	20	44	0.58
		Down gradient	Shinarump member of the Chinle Formation	15	7	46	0.17
		Down gradient	DeChelly member of the Cutler Formation	8	3	37	0.11

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Molybdenum	0.10	Background	Alluvium	7	1	14	0.11
		Background	Shinarump member of the Chinle Formation	10	4	40	0.22
		Background	DeChelly member of the Cutler Formation	9	4	44	0.19
		Cross-gradient	Alluvium	4	2	50	0.19
		Cross-gradient	Shinarump member of the Chinle Formation	2	1	50	0.16
		Cross-gradient	DeChelly member of the Cutler Formation	6	5	83	0.21
		On-Site	DeChelly member of the Cutler Formation	7	---	---	---
		Down gradient	Alluvium	44	37	84	0.35
		Down gradient	Shinarump member of the Chinle Formation	15	14	93	0.25
		Down gradient	DeChelly member of the Cutler Formation	8	8	100	0.24

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Nitrate 2/	44	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10			
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	15	34	1200
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	2	22	9.36
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	1	2	9.68
		Down gradient	Shinarump member of the Chinle Formation	15	1	6	8.65
		Down gradient	DeChelly member of the Cutler Formation	8	4	50	9.89

TABLE 4-16

Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfate	250	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	28	63	3130
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-16

Site Name: Monument Valley (Arizona)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Alluvium	6	3	50	0.10
		Background	Shinarump member of the Chinle Formation	9	7	77	0.10
		Background	DeChelly member of the Cutler Formation	7	4	57	0.10
		Cross-gradient	Alluvium	4	2	50	0.10
		Cross-gradient	Shinarump member of the Chinle Formation	2	1	50	0.10
		Cross-gradient	DeChelly member of the Cutler Formation	6	1	16	0.10
		On-Site	DeChelly member of the Cutler Formation	8	6	75	0.10
		Down gradient	Alluvium	34	28	82	0.10
		Down gradient	Shinarump member of the Chinle Formation	12	7	58	0.10
		Down gradient	DeChelly member of the Cutler Formation	5	5	100	0.10

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Total Solids	500	Background	Alluvium	7	2	28	626
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	28	63	5590
		Down gradient	Shinarump member of the Chinle Formation	15	6	40	730
		Down gradient	DeChelly member of the Cutler Formation	8	2	25	563

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Alluvium	7	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	9	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	1	13	0.0514

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Zinc	5.0	Background	Alluvium	6	---	---	---
		Background	Shinarump member of the Chinle Formation	10	---	---	---
		Background	DeChelly member of the Cutler Formation	8	---	---	---
		Cross-gradient	Alluvium	4	---	---	---
		Cross-gradient	Shinarump member of the Chinle Formation	2	---	---	---
		Cross-gradient	DeChelly member of the Cutler Formation	6	---	---	---
		On-Site	DeChelly member of the Cutler Formation	8	---	---	---
		Down gradient	Alluvium	44	---	---	---
		Down gradient	Shinarump member of the Chinle Formation	15	---	---	---
		Down gradient	DeChelly member of the Cutler Formation	8	---	---	---

TABLE 4-16
Site Name: Monument Valley (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybedum
Data Interval: 06/08/82 to 04/30/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.10 RIVERTON, WYOMING - SUMMARY OF WATER QUALITY

The Riverton process site lies on the floodplain of the Wind and Little Wind Rivers. The site rests on, in descending order, recent alluvium and beds of the Wind River Formation. There are two aquifers in the site vicinity; the water table (unconfined)aquifer consisting of alluvium and the uppermost sandstone of the Wind River Formation (2) the confined aquifer consisting of deeper sandstone beds. Contamination is restricted largely to the unconfined aquifer. Historically the unconfined aquifer within the plume area has had limited use; currently, the aquifer is not being used in this area. The confined aquifer does not appear to be contaminated.

Groundwater sampling indicated that limits of concentration of gross alpha were exceeded. The one on-site gravel analyzed for gross alpha exceeded the standard by more than a factor of 17. Concentrations of arsenic, chromium, barium, silver, cadmium, mercury, radium, lead and selenium were below the limits for the standard.

Groundwater discharges to the Little Wind River, approximately 3000 feet from the site. Modeling indicates that it will take 45 to 65 years for the mobile contaminants to completely flush from the unconfined aquifer. Based on the present location of the molybdenum plume relative to the sulfate plume, it may take 200 to 300 years to flush molybdenum from the system.

TABLE 4-17
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Barium	1.0	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-17
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Cadmium	0.01	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Chromium	0.05	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-17
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Gravel or sandy gravel, poorly graded	9	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	1	1	100	260.8
		On-Site	Sandstone	10	1	10	65.2
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Lead	0.05	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-17
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Mercury	0.002	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	16	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	2 2/	---	---	---
		On-Site	Sandstone	7	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-17
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Silver	0.05	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	16	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Analyses for Ra-226 only.
--- Standard not exceeded.

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Gravel or sandy gravel, poorly graded	9	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	2	---	---	---
Copper	1.0	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Fluoride	1.4	Background	Gravel or sandy gravel, poorly graded	9	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	16	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	2	---	---	---
Hydrogen Sulfide	0.05	Background	Gravel or sandy gravel, poorly graded	1	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	1	---	---	---
		On-Site	Sandstone	1	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	1	---	---	---

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	4	19	0.75
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Manganese	0.05	Background	Gravel or sandy gravel, poorly graded	8	8	100	2.26
		On-Site	Gravel or sandy gravel, poorly graded	3	3	100	0.23
		On-Site	Sandstone	21	21	100	5.20
		Down gradient	Gravel or sandy gravel, poorly graded	1	1	100	1.05
		Down gradient	Sandstone	3	---	---	---

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Molybdenum	0.10	Background	Gravel or sandy gravel, poorly graded	8	--	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	4	19	1.69
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Nitrate 2/	44	Background	Gravel or sandy gravel, poorly graded	9	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Background	Gravel or sandy gravel, poorly graded	12	1	8	9.35
		On-Site	Gravel or sandy gravel, poorly graded	1	---	---	---
		On-Site	Sandstone	15	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	3	---	---	---
		Down gradient	Sandstone	3	3	100	12.26
Sulfate	250	Background	Gravel or sandy gravel, poorly graded	9	2	22	376
		On-Site	Gravel or sandy gravel, poorly graded	3	3	100	577
		On-Site	Sandstone	21	19	90	747
		Down gradient	Gravel or sandy gravel, poorly graded	1	1	100	461
		Down gradient	Sandstone	2	1	50	286

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfide	0.05	Background	Gravel or sandy gravel, poorly graded	9	9	100	0.10
		On-Site	Gravel or sandy gravel, poorly graded	1	---	---	---
		On-Site	Sandstone	7	7	100	0.10
		Down gradient	Gravel or sandy gravel, poorly graded	1	1	100	0.10
		Down gradient	Sandstone	3	3	100	0.10
Total Solids	500	Background	Gravel or sandy gravel, poorly graded	9	2	22	950
		On-Site	Gravel or sandy gravel, poorly graded	3	3	100	1410
		On-Site	Sandstone	21	19	90	1450
		Down gradient	Gravel or sandy gravel, poorly graded	1	1	100	1100
		Down gradient	Sandstone	2	2	100	1172

TABLE 4-18

Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Gravel or sandy gravel, poorly graded	9	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	2	2	100	0.415
		On-Site	Sandstone	13	2	15	0.305
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---
Zinc	5.0	Background	Gravel or sandy gravel, poorly graded	8	---	---	---
		On-Site	Gravel or sandy gravel, poorly graded	3	---	---	---
		On-Site	Sandstone	21	---	---	---
		Down gradient	Gravel or sandy gravel, poorly graded	1	---	---	---
		Down gradient	Sandstone	3	---	---	---

TABLE 4-18
Site Name: Riverton (Wyoming)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 12/02/83 to 06/05/85

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.11 SALT LAKE CITY, UTAH - SUMMARY OF WATER QUALITY

The groundwater regime at the Vitro site is generally characterized by two aquifer systems, a near-surface unconfined system and a deeper confined system. Near the site, both aquifers flow generally to the west-northwest. The unconfined aquifer discharges into local surface water courses.

Water in the unconfined aquifer is of brackish quality with high total dissolved solids, generally 2000 ppm or greater, and sulfates on the order of 800 ppm or greater. Due to its poor quality and low yields, this water has only very limited use. Water in the confined aquifer generally has dissolved solids concentrations of about 300 ppm and a sulfate content of about 20 ppm. This aquifer is an important source of water for domestic, agricultural and industrial uses in the Salt Lake Valley.

In the unconfined aquifer, arsenic, iron and manganese values exceeded standards in some up-, cross- and downgradient samples, with no clear trend evident. Gross alpha and radium (Ra-226 and 228) values also exceeded standards in some up-, cross- and downgradient samples, with significantly higher values in downgradient samples. Some samples from up-, cross- and downgradient exceeded standards for total dissolved solids, chloride and sulfate, with a larger percentage of samples exceeding standards and somewhat higher values in downgradient samples.

In the confined aquifer, some downgradient samples exceeded standards for total dissolved solids and sulfate. Iron values exceeded standards in up-, cross- and downgradient samples, but the percentage of samples exceeding standards was higher and the extent of the difference between the measured values and the standards was greater in the downgradient samples.

The unconfined groundwater aquifer discharges to the Jordan River and Mill Creek. Contaminant plumes have not been modeled.

TABLE 4-19

Site Name: Salt Lake City, Utah
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 1982 and 1983

Constituent	Standard (mg/l) 1/	Aquifer	Hydraulic Flow Relationship	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Unconfined	Upgradient	14	11	79	0.245
			Crossgradient	8	---	---	---
			Downgradient	29	4	14	0.5
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	14	---	---	---
Barium	1.0	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Cadmium	0.01	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Chromium	0.05	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	1	12	0.08
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Unconfined	Upgradient	10	6	60	600
			Crossgradient	8	3	37	85.2
			Downgradient	29	24	83	1181
		Confined	Upgradient	3	2	67	30
			Crossgradient	2	1	50	30
			Downgradient	13	4	31	100
Lead	0.05	Unconfined	Upgradient	14	2	14	0.3
			Crossgradient	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---

TABLE 4-19

Site Name: Salt Lake City, Utah
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 1982 and 1983

Constituent	Standard (mg/1) 1/	Aquifer	Hydraulic Flow Relationship	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/1) 1/
Mercury	0.002	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	1	3	0.003
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Unconfined	Upgradient	10	1	10	14
			Crossgradient	8	3	37	12.5
			Downgradient	27	5	18	114
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	1	50	5.1
			Downgradient	12	1	8	9.1
Selenium	0.01	Unconfined	Upgradient	14	---	---	---
			Crossgradien	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Silver	0.05	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---

1/ Values are reported in mg/1 unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-20

Site Name: Salt Lake City, Utah

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 1982 and 1983

Constituent	Standard (mg/l) 1/	Aquifer	Hydraulic Flow Relationship	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Unconfined	Upgradient	9	5	56	4900
			Crossgradient	5	5	100	2883
			Downgradient	21	17	81	5400
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	14	5	36	410
Copper	1.0	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Fluoride	1.4	Unconfined	Upgradient	1	---	---	---
			Crossgradient	4	---	---	---
			Downgradient	5	5	100	6.1
		Confined	Upgradient	1	---	---	---
			Crossgradient	1	---	---	---
			Downgradient	4	---	---	---
Hydrogen Sulfide	0.05	Unconfined	Upgradient	1	---	---	---
			Crossgradient	4	---	---	---
			Downgradient	6	2	33	0.08
		Confined	Upgradient	1	---	---	---
			Crossgradient	1	1	100	0.09
			Downgradient	4	1	25	0.07
Iron	0.3	Unconfined	Upgradient	15	8	53	70
			Crossgradient	8	6	75	44
			Downgradient	35	25	71	58
		Confined	Upgradient	3	1	33	0.61
			Crossgradient	3	2	67	0.92
			Downgradient	17	11	65	4.6
Manganese	0.05	Unconfined	Upgradient	8	7	87	1.6
			Crossgradient	6	6	100	1.85
			Downgradient	18	17	94	4.02
		Confined	Upgradient	1	---	---	---
			Crossgradient	2	2	100	1.5
			Downgradient	10	10	100	0.60

TABLE 4-20

Site Name: Salt Lake City, Utah
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 1982 and 1983

Constituent	Standard (mg/1) 1/	Aquifer	Hydraulic Flow Relationship	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/1) 1/
Molybdenum	0.10	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	1	3	0.2
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---
Nitrate 2/	44	Unconfined	Upgradient	5	---	---	---
			Crossgradient	6	---	---	---
			Downgradient	12	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	6	1	17	---
pH 3/	6.5 to 8.5	Unconfined	Upgradient	12	---	---	---
			Crossgradient	6	---	---	---
			Downgradient	25	---	---	---
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	14	---	---	---
Sulfate	250	Unconfined	Upgradient	9	4	44	4300
			Crossgradient	5	5	100	2000
			Downgradient	21	18	86	7800
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	14	5	36	590
Total Solids	500	Unconfined	Upgradient	12	10	83	16100
			Crossgradient	5	5	100	6002
			Downgradient	25	22	88	21000
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	15	11	73	1800
Uranium 4/	0.044	Unconfined	Upgradient	11	---	---	---
			Crossgradient	8	1	12	31.1
			Downgradient	33	24	73	2.24
		Confined	Upgradient	3	---	---	---
			Crossgradient	2	---	---	---
			Downgradient	16	---	---	---

TABLE 4-20

Site Name: Salt Lake City, Utah

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 1982 and 1983

Constituent	Standard (mg/1) 1/	Aquifer	Hydraulic Flow Relationship	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/1) 1/
Zinc	5.0	Unconfined	Upgradient	14	---	---	---
			Crossgradient	8	---	---	---
			Downgradient	29	1	3	110
		Confined	Upgradient	3	---	---	---
			Crossgradient	3	---	---	---
			Downgradient	13	---	---	---

1/ Values are reported in mg/1 unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/1 is equivalent to concentration of nitrate as nitrate at a level of 44 mg/1. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/1 of uranium is equivalent of 0.044 mg/1, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/1.
--- Standard not exceeded.

4.12 SHIPROCK, NM - SUMMARY OF WATER QUALITY

The Shiprock site is in northwestern New Mexico and rests on the escarpment above the floodplain of the San Juan River. The remedial action is complete. The underlying groundwater (divided into two units) is definitely contaminated. Groundwater in the floodplain unit has been used and is potentially useable in the future; contamination in the floodplain appears to be relict, i.e., from past discharges. A key issue is the extent and characteristics of the flood-plain contamination. The second groundwater unit is perched within the soils and fractured Mancos Shale on the escarp-ment above the floodplain.

Chromium, selenium and silver exceeded the standard for some samples. Eight out of 29 analysis for chromium down gradi-ent samples exceed the standard. One of 29 down gradient samples exceeded the standard for silver. Thirteen of 77 down gradient selenium samples exceeded standards. Arsenic, barium, cadmium, gross alpha, lead, mercury, and radium concentrations are within limits of the standards.

Contaminated water occurs in the floodplain. Groundwater in the alluvium discharges to the San Juan River. The contami-nant plume has not been modeled; existing data show little if any flushing of contaminants in the alluvium.

TABLE 4-21
Site Name: Shiprock (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 10/16/84 to 09/20/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	---	---	---
Barium	1.0	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	---	---	---
Cadmium	0.01	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	---	---	---
Chromium	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	8	27	0.11
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Upgradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
Lead	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	---	---	---
Mercury	0.002	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	---	---	---

TABLE 4-21

Site Name: Shiprock (New Mexico)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)

Data Interval: 10/16/84 to 09/20/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Upgradient	Alluvium	2 2/	---	---	---
		Down gradient	Alluvium	23	---	---	---
Selenium	0.01	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	13	16	0.91
Silver	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	29	1	3	0.10

1/ Values are reported in mg/l unless otherwise indicated.
2/ Analyses for Ra-226 only.
--- Standard not exceeded.

TABLE 4-22
Site Name: Shiprock (New Mexico)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 10/16/84 to 09/20/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	27	35	2200
Copper	1.0	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	---	---	---
Fluoride	1.4	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	48	62	14.0
Hydrogen Sulfide	0.05	Upgradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	1	---	---	---
Iron	0.30	Upgradient	Alluvium	2	1	50	1.14
		Down gradient	Alluvium	77	18	23	2.05
Manganese	0.05	Upgradient	Alluvium	2	2	100	0.74
		Down gradient	Alluvium	77	76	98	9.60
Molybdenum	0.10	Upgradient	Alluvium	2	1	50	0.16
		Down gradient	Alluvium	77	53	69	0.44
Nitrate 2/	44	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	57	77	3600

TABLE 4-22

Site Name: Shiprock (New Mexico)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 10/16/84 to 09/20/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Upgradient	Alluvium	2	---	---	---
		Down·gradient	Alluvium	77	---	---	---
Sulfate	250	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	77	100	19,200
Sulfide	0.05	Upgradient	Alluvium	1	1	100	0.10
		Down gradient	Alluvium	23	23	200	0.10
Total Solids	500	Upgradient	Alluvium	2	1	50	534
		Down gradient	Alluvium	77	77	100	32,600
Uranium 4/	0.044	Upgradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	71	55	77	7.21
Zinc	5.0	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	77	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.13 TUBA CITY, ARIZONA - SUMMARY OF WATER QUALITY

The Tuba City site is located in northeastern Arizona about five miles east of Tuba City. The site rests on the Navajo Sandstone which contains the primary water source in the area. Background monitor wells reveal good water quality (TDS < 500 mg/l) with minor exceptions. The tailings pile has contaminated approximately one billion gallons of groundwater.

Cadmium concentrations were higher in on-site and down gradient samples than in background or upgradient samples. Seven of 48 down gradient analyses for chromium and four of 13 upgradient analyses for radium exceeded the limit for the standard. Maximum selenium concentrations exceeded the standard by a factor of 6. One of 4 on-site samples for gross alpha, as well as one of 14 down gradient samples, exceed the standard for gross alpha.

Groundwater flow and at least partial discharge of contaminated water is into the Moenkopi Wash, about 2 miles from the edge of the tailing pile. Modeling shows discharge of the trailing edge of the mobile contaminant plume to Moenkopi Wash in 300 years. Discharge of the uranium plume was not modeled but is estimated to be several hundred years after the mobile plume.

TABLE 4-23
Site Name: Tuba City (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	---	---	---
Barium	1.0	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	---	---	---
Cadmium	0.01	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	18	---	---	---
		On-Site	Navajo Sandstone	6	4	66	0.031
		Down gradient	Navajo Sandstone	48	10	20	0.039
Chromium	0.05	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	18	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	48	7	14	0.08

TABLE 4-23
Site Name: Tuba City (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Gross Alpha (excluding radon and uranium)	15.0 pCi/l	Background	Navajo Sandstone	4	---	---	---
		Upgradient	Navajo Sandstone	9	---	---	---
		On-Site	Navajo Sandstone	4	1	25	33.2
		Down gradient	Navajo Sandstone	14	1	7	27.2
Lead	0.05	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	1	5	0.06
Mercury	0.002	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	1	5	0.0029
Ra-226 + Ra-228 (Radium)	5.0 pCi/l	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	13	4	30	7.0
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	---	---	---
Selenium	0.01	Background	Navajo Sandstone	10	1	10	0.018
		Upgradient	Navajo Sandstone	18	---	---	---
		On-Site	Navajo Sandstone	6	6	100	0.039
		Down gradient	Navajo Sandstone	48	10	20	0.066

TABLE 4-23
Site Name: Tuba City (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Silver	0.05	Background	Navajo Sandstone	8	1	12	0.10
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	33	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-24

Site Name: Tuba City (Arizona)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	17	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	48	---	---	---
Copper	1.0	Background	Navajo Sandstone	8	---	---	---
		Upgradient	Navajo Sandstone	13	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	33	---	---	---
Fluoride	1.4	Background	Navajo Sandstone	6	---	---	---
		Upgradient	Navajo Sandstone	12	2	16	4.60
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	20	---	---	---
Hydrogen Sulfide	0.05	Background	Navajo Sandstone	1	---	---	---
		Upgradient	Navajo Sandstone	1	---	---	---
		On-Site	Navajo Sandstone	1	---	---	---
		Down gradient	Navajo Sandstone	1	---	---	---

TABLE 4-24

Site Name: Tuba City (Arizona)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Iron	0.30	Background	Navajo Sandstone	8	---	---	---
		Upgradient	Navajo Sandstone	13	3	23	2.25
		On-Site	Navajo Sandstone	6	3	50	1.14
		Down gradient	Navajo Sandstone	33	1	3	1.96
Manganese	0.05	Background	Navajo Sandstone	8	---	---	---
		Upgradient	Navajo Sandstone	9	1	11	0.10
		On-Site	Navajo Sandstone	6	6	100	2.40
		Down gradient	Navajo Sandstone	33	11	33	0.35
Molybdenum	0.10	Background	Navajo Sandstone	8	3	38	0.21
		Upgradient	Navajo Sandstone	18	5	27	0.20
		On-Site	Navajo Sandstone	6	1	17	0.21
		Down gradient	Navajo Sandstone	48	28	58	0.24
Nitrate 2/	44	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	17	---	---	---
		On-Site	Navajo Sandstone	6	6	100	1800
		Down gradient	Navajo Sandstone	48	24	50	1500

TABLE 4-24
Site Name: Tuba City (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5 to 8.5	Background	Navajo Sandstone	10	7	70	10.10
		Upgradient	Navajo Sandstone	18	1	5	8.79
		On-Site	Navajo Sandstone	6	4	66	6.19
		Down gradient	Navajo Sandstone	48	25	52	6.33/12.75
Sulfate	250	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	17	---	---	---
		On-Site	Navajo Sandstone	6	6	100	2600
		Down gradient	Navajo Sandstone	48	20	41	4010
Sulfide	0.05	Background	Navajo Sandstone	4	4	100	0.10
		Upgradient	Navajo Sandstone	8	8	100	0.10
		On-Site	Navajo Sandstone	4	4	100	0.10
		Down gradient	Navajo Sandstone	17	17	100	0.10
Total Solids	500	Background	Navajo Sandstone	10	---	---	---
		Upgradient	Navajo Sandstone	13	1	7	600
		On-Site	Navajo Sandstone	6	6	100	7000
		Down gradient	Navajo Sandstone	48	29	60	8550

TABLE 4-24
Site Name: Tuba City (Arizona)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/09/82 to 04/11/86

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Navajo Sandstone	8	---	---	---
		Upgradient	Navajo Sandstone	17	---	---	---
		On-Site	Navajo Sandstone	4	4	100	2.40
		Down gradient	Navajo Sandstone	45	19	42	0.21
Zinc	5.0	Background	Navajo Sandstone	8	---	---	---
		Upgradient	Navajo Sandstone	9	---	---	---
		On-Site	Navajo Sandstone	6	---	---	---
		Down gradient	Navajo Sandstone	33	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

GREEN RIVER--SUMMARY OF WATER QUALITY

This site is located in the floodplain of Brown's Wash, an intermittent tributary of the Green River which flows southward and discharges into the Colorado River about 60 miles south of Green River, Utah. The site is on the nose of shallow north plunging anticline that is repeated by the arcuate eastnortheast-westnorthwest trending Little Grand Wash fault three miles south of the site. Sedimentary units of Cretaceus and Jurassic age outcrop in the area; units at the site include the Quaternary Brown's Wash alluvium underlying the tailings pile and alluvial terrace deposits beneath the proposed disposal site. These are underlain by the Tununk Shale Member of the Mancos Shale, the Dakota Sandstone and the Cedar Mountain Formation, all of Cretaceous age. Four distinct water-bearing units were defined within the upper 200 feet of Quaternary and Cretaceous sediments at the site. These are, from the surface down:

-the zero to 35 feet thick Brown's Wash alluvium is comprised of silt, sand, gravel and some small cobbles and extends 300 to 400 feet on either side of Brown's Wash. A paleochannel of Brown's Wash has eroded away the Dakota Sandstone beneath the tailings site, and the alluvium directly overlies shale of the Cedar Mountain Formation; this unit does not extend south of the tailings pile or under the proposed disposal site. Groundwater of this unit is locally perched;

-the upper-middle unit is comprised of up to 30 feet of alternating layers of shale, limestone and mudstone of the Cedar Mountain Formation; this unit is continuous beneath both the existing and proposed tailings sites;

-the lower-middle unit is a relatively thick but laterally limited sandstone and conglomerate channel deposit within the Cedar Mountain Formation; this unit intertongues with the middle-upper unit and also is continuous beneath both tailings sites;

-the bottom unit is the 15 to 25 feet thick Buckhorn Conglomerate Member of the Cedar Mountain Formation; this basal sandstone and sandstone conglomerate unit is confined by overlying shale and mudstone and is continuous beneath both tailings sites.

Contamination from the tailings pile is confined to the upper two units by strong upward hydraulic gradients between the upper-middle unit and the underlying units; the maximum depth of contamination at the site is about 65 feet (DOE-88). In both the top and upper middle units gross alpha activity, molybdenum, nitrate, selenium and uranium exceed background levels and proposed EPA and State of Utah groundwater standards beneath and downgradient of the tailings.

TABLE 4-26 (continued)
Site Name: Green River (Utah)
Data Evaluation: Site Water Quality Compared to U. S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 7/14/82 - 1/12/88

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Manganese	0.05	Background	Alluvium	13	1	8	0.06
			Shale	4	2	50	0.21
			Conglomerate	9	7	78	0.49
			Sandstone	10	---	---	---
		Upgradient	Shale	2	---	---	---
			Sandstone	6	---	---	---
		Cross-gradient	Alluvium	5	---	---	---
			Conglomerate	5	2	40	0.87
		On-site	Alluvium	21	11	52	0.98
			Shale	6	2	33	2.3
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	---	---	---
			Shale	16	5	31	0.21
			Conglomerate	2	---	---	---
			Sandstone	6	---	---	---
Molybdenum	0.10	Background	Alluvium	13	5	38	0.20
			Shale	4	---	---	---
			Conglomerate	9	4	44	0.22
			Sandstone	10	1	10	0.14
		Upgradient	Shale	2	1	50	0.11
			Sandstone	6	---	---	---
		Cross-gradient	Alluvium	5	2	40	0.13
			Conglomerate	5	2	40	0.15
		On-site	Alluvium	21	8	38	0.27
			Shale	6	6	100	0.20
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	2	50	0.104
			Shale	16	---	---	---
			Conglomerate	2	---	---	---
			Sandstone	6	---	---	---

TABLE 4-26 (continued)
Site Name: Green River (Utah)
Data Evaluation: Site Water Quality Compared to U. S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 7/14/82 - 1/12/88

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Nitrate 2/	44	Background	Alluvium	13	3	23	140
			Shale	4	2	50	93
			Conglomerate	9	6	67	173
			Sandstone	10	---	---	---
		Upgradient	Shale	2	2	100	975
			Sandstone	6	---	---	---
		Cross-gradient	Alluvium	5	---	---	---
			Conglomerate	5	---	---	---
		On-site	Alluvium	21	943440		
			Shale	6	6	100	2480
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	---	---	---
			Shale	16	2	13	71
			Conglomerate	2	---	---	---
			Sandstone	6	---	---	---
pH 3/	6.5-8.5	Background	Alluvium	13	---	---	---
			Shale	4	---	---	---
			Conglomerate	9	---	---	---
			Sandstone	10	6	60	11.61
		Upgradient	Shale	2	---	---	---
			Sandstone	6	1	17	8.65
		Cross-gradient	Alluvium	5	---	---	---
			Conglomerate	5	---	---	---
		On-site	Alluvium	21	---	---	---
			Shale	6	---	---	---
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	---	---	---
			Shale	16	2	13	9.08
			Conglomerate	2	---	---	---
			Sandstone	6	1	17	8.84

TABLE 4-26 (continued)
Site Name: Green River (Utah)
Data Evaluation: Site Water Quality Compared to U. S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 7/14/82 - 1/12/88

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfate	250	Background	Alluvium	13	13	100	6210
			Shale	4	4	100	3940
			Conglomerate	9	9	100	4600
			Sandstone	10	10	100	1193
		Upgradient	Shale	2	2	100	4160
			Sandstone	6	4	67	674
		Cross-gradient	Alluvium	5	5	100	6280
			Conglomerate	5	5	100	700
		On-site	Alluvium	21	21	100	6890
			Shale	6	7	100	3610
			Conglomerate	4	4	100	2570
		Down gradient	Alluvium	2	2	100	5000
			Shale	16	16	100	3270
			Conglomerate	2	2	100	572
			Sandstone	6	6	100	2120
Total Solids	500	Background	Alluvium	13	13	100	9560
			Shale	4	4	100	7300
			Conglomerate	9	9	100	7980
			Sandstone	10	10	100	2480
		Upgradient	Shale	2	2	100	9540
			Sandstone	6	6	100	2170
		Cross-gradient	Alluvium	5	5	100	10400
			Conglomerate	5	5	100	2120
		On-site	Alluvium	21	21	100	10800
			Shale	6	7	100	7160
			Conglomerate	4	4	100	4790
		Down gradient	Alluvium	2	2	100	8030
			Shale	16	16	100	6200
			Conglomerate	2	2	100	2930
			Sandstone	6	6	100	3820

TABLE 4-26 (continued)
Site Name: Green River (Utah)
Data Evaluation: Site Water Quality Compared to U. S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 7/14/82 - 1/12/88

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Uranium 4/	0.044	Background	Alluvium	13	---	---	---
			Shale	4	---	---	---
			Conglomerate	9	5	56	0.146
			Sandstone	10	---	---	---
		Upgradient	Shale	2	---	---	---
			Sandstone	6	---	---	---
		Cross-gradient	Alluvium	5	---	---	---
			Conglomerate	5	---	---	---
		On-site	Alluvium	21	21	100	2.23
			Shale	6	7	100	3.11
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	1	50	0.554
			Shale	16	---	---	---
			Conglomerate	2	---	---	---
			Sandstone	6	---	---	---
Zinc	5.0	Background	Alluvium	13	---	---	---
			Shale	4	---	---	---
			Conglomerate	9	---	---	---
			Sandstone	10	---	---	---
		Upgradient	Shale	2	---	---	---
			Sandstone	6	---	---	---
		Cross-gradient	Alluvium	5	---	---	---
			Conglomerate	5	---	---	---

TABLE 4-26 (continued)
Site Name: Green River (Utah)
Data Evaluation: Site Water Quality Compared to U. S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 7/14/82 - 1/12/88

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
		On-site	Alluvium	21	---	---	---
			Shale	6	---	---	---
			Conglomerate	4	---	---	---
		Down gradient	Alluvium	2	---	---	---
			Shale	16	---	---	---
			Conglomerate	2	---	---	---
			Sandstone	6	---	---	---

1/ Values are reported in mg/l unless otherwise indicated. 2/ Concentrations of nitrate as nitrogen at a level of 10 mg.l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate. 3/ pH reported in standard units. 4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.--- Standard not exceeded.

RIFLE (OLD AND NEW SITES) - SUMMARY OF WATER QUALITY

Both sites are located on the floodplain alluvium of the Colorado River valley. Of the four aquifers in the Rifle area, only two are affected by the tailings piles - the unconfined alluvium and the underlying Wasatch Formation. (DOE 87)

The alluvial aquifer is about 20 feet thick at the old site and 25 to 30 feet thick at the new site, with depths to water ranging from 2 to 12 feet below land surface. Recharge of the aquifer is primarily from the Colorado River and its tributaries; discharge at the site is primarily to the Colorado River, though there is some groundwater flow between the alluvial aquifer and the underlying Wasatch aquifer. Water levels are influenced by the Colorado River and fluctuate more than 7 feet annually, being highest in the summer and lowest in the winter. Groundwater flow is generally westward, roughly parallel to the Colorado River channel. Discharge from a drainage ditch at the north edge of the pile at the old site percolates through the alluvium, causing a groundwater mound beneath the pile in that area.

Ground water within the Wasatch Formation is confined by shales and claystones of low permeability, interbedded with more permeable sand-stones. Hydraulic heads are 10 to 20 feet above the Wasatch-alluvium contact. The primary recharge area for the Wasatch is probably the Grand Hogback, an area of nearly vertical strata. Flow seems to be generally westward but is poorly defined because of anomalous water levels resulting from the discontinuous character of the Wasatch strata. Drainage is to the alluvial aquifer along the Colorado River and, probably, to its tributaries.

In the alluvial aquifer, analsyes show that sodium and calcium are the dominant cations and sulfate and bicarbonate are the dominant anions. The water is neutral pH and has a mean TDS concentration of 1900 mg/l. Fluoride exceeds the EPA primary drinking water standards in one well at the new site.Gross alpha levels exceeded EPA primary standards in a number of samples but are believed to result from the high levels of naturally occurring uranium in the water. Manganese, iron and chlorine levels in several wells and sulfate and TDS levels in nearly all of the wells exceeded EPA secondary standards. Even though much of the alluvial water in the area is in Use Category 1 under the Colorado classification system, it may not be suitable for domestic purposes because of the high levels of natural contaminants.

The Wasatch aquifer is much higher in sodium and chloride and lower in calcium and sulfate than the alluvial aquifer. The water is slightly alkaline and has a mean TDS concentration of about 3600 mg/l. Back-ground levels for some constituents exceed EPA primary drinking water standards: barium (2 of 7 samples), radium-226 and radium-228 combined (1 of 5 samples), fluoride (1 of 7 samples). Also, background levels exceed EPA secondary drinking water standards for several constituents: chloride (17 of 19 samples), pH was over 8.5 in 7 samples, sulfate (4 of 19 samples), and TDS was over 500 mg/l in all wells. Of the 19 wells monitored, 13 are in Use Category 1, 5 in Use Category 2 and 1 is Use Category 3 under Colorado's classification system. However, the high concentrations of naturally occurring contaminants may preclude domestic use of the Wasatch Formation water.

At the Old Rifle site, one or more of the monitoring wells showed elevated levels of arsenic, lead-210, radium-226, radium-228, sulfate, thorium-230, uranium and vanadium. Of these, uranium was the only constituent showing a substantial increase being 20 times background in one well. In a monitor well 360 feet downgradient, to the southwest, the only constituent indicating contamination was ammonium which was only slightly above background levels. Though there is ittle evidence of lateral movement of leachate from the pile, the alluvial aquifer does appear to be contaminated down to its contact with the Wasatch Formation. There are no monitor wells into the Wasatch at or near the periphery of the Old Rifle tailings so no samples of the confined aquifer are available in this area. Contamination of this aquifer would probable be minor and localized to the area immediately beneath the tailings.

The contaminant plume extends less than 800 feet downgradient from the pile and probably discharges into the Colorado River within this distance. Minimum flushing time, once the tailings are removed is estimated to be 1.9 years.

At the New Rifle site, both the alluvial and Wasatch aquifers are contaminated; in each case, the area of contamination is defined by the sulfate plume. The entire saturated thickness (15 to 20 feet) of the alluvial aquifer is contaminated over an area of at least 400 acres. Contaminant concentrations are highest directly under and west of the tailings pile and the vanadium ponds. Some contaminated water may discharge into the Colorado River 3000 feet southwest of the tailings pile; contamination can also be detected in a well 8000 feet west of the pile. Uranium levels ranged from 3 to 44 times background, molybdenum from 25 to 150 times background in 2 discrete localized plumes, sulfate from about 2 to over 40 times background, ammonium from 525 to over 16000 times background, nitrate concentrations are inversely related to the ammonium levels, and chloride levels were up to 11 times background (DOE87). Three contaminants have been identified in the Wasatch Formation aquifer: uranium (up to 200 times background), molybdenum (up to 16 times background), and sulfate (up to 117 times background) (DOE87).

The sulfate plume in the alluvial aquifer extends at least 7000 feet downgradient from the tailings pile and the plume in the Wasatch extends for 3000 feet downgradient; both plumes appear to be actively augmented by the tailings pile. Calculations indicate that, once the tailings are removed, the plumes would be completely dispersed or discharged to the Colorado River within 2 miles downgradient of the tailings pile. The estimated minimum flushing times are 45 years for the alluvial aquifer and 3840 years for the Wasatch Formation aquifer.

TABLE 4-27

Site Name: Rifle (New Site)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---
Barium	1.0	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---
Cadmium	0.01	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	1	4	0.03
		On-Site	Alluvium	3	2	67	0.03
		Down gradient	Wasatch	13	---	---	---
Chromium	0.05	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	2	8	0.25
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---
Gross Alpha	15pCi	Cross-gradient	Alluvium	1	1	100	213
		Down gradient	Alluvium	24	8	34	660
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	2	15	340
Lead	0.05	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---
Ra-226 + Ra-228 (Radium)	5.0pCi	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---

TABLE 4-27
Site Name: Rifle (New Site)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	7	29	0.16
		On-Site	Alluvium	3	1	33	0.041
		Down gradient	Wasatch	13	3	23	0.2
Silver	0.05	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-28

Site Name: Rifle (New Site)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	22	92	1360
		On-Site	Alluvium	3	3	100	1400
		Down gradient	Wasatch	13	13	100	4200
Copper	1.0	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	---	---	---
Fluoride	1.4	Cross-gradient	Alluvium	1	1	100	2.2
		Down gradient	Alluvium	24	3	12	6.1
		On-Site	Alluvium	3	1	33	9
		Down gradient	Wasatch	13	2	15	5.6
Iron	0.3	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	9	38	67
		On-Site	Alluvium	3	3	100	44.1
		Down gradient	Wasatch	13	9	69	152
Manganese	0.05	Cross-gradient	Alluvium	1	1	100	8.03
		Down gradient	Alluvium	24	24	100	53.9
		On-Site	Alluvium	3	3	100	19.6
		Down gradient	Wasatch	13	11	85.	18.8
Molybdenum	0.10	Cross-gradient	Alluvium	1	1	100	3.0
		Down gradient	Alluvium	24	12	50	9.2
		On-Site	Alluvium	3	3	100	12.7
		Down gradient	Wasatch	13	11	85	5.07
Nitrate 2/	10	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	13	54	920
		On-Site	Alluvium	3	1	33	310
		Down gradient	Wasatch	13	6	46	97

TABLE 4-28

Site Name: Rifle (New Site)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
pH 3/	6.5-8.5	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	---	---	---
		Down gradient	Wasatch	13	4	31	10.69
Sulfate	250	Cross-gradient	Alluvium	1	1	100	2150
		Down gradient	Alluvium	24	24	100	29100
		On-Site	Alluvium	3	3	100	34000
		Down gradient	Wasatch	13	13	100	30300
Total Solids	500	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	20	20	100	42050
		On-Site	Alluvium	3	3	100	69300
		Down gradient	Wasatch	13	13	100	44000
Uranium 4/	0.044	Cross-gradient	Alluvium	1	1	100	0.428
		Down gradient	Alluvium	24	16	67	0.9070
		On-Site	Alluvium	3	2	67	1.31
		Down gradient	Wasatch	13	7	54	0.67
Zinc	5.0	Cross-gradient	Alluvium	1	---	---	---
		Down gradient	Alluvium	24	---	---	---
		On-Site	Alluvium	3	1	33	6.3

1/ Values are reported in mg/l unless otherwise indicated.

2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.

3/ pH reported in standard units.

4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.

--- Standard not exceeded.

TABLE 4-29

Site Name: Rifle (Old Site)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Arsenic	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	1	17	0.23
		Upgradient	Wasatch	2	---	---	---
Barium	1.0	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
Cadmium	0.01	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
Chromium	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
Gross Alpha	15pCi	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
		Upgradient	Wasatch	2	---	---	---
Lead	0.05	Upgradient	Alluvium	2	2	100	81
		Down gradient	Alluvium	2	2	100	68
		On-Site	Alluvium	6	6	100	980
		Upgradient	Wasatch	2	2	100	22
Ra-226 + Ra-228	5.0pCi	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	2	34	104.6
		Upgradient	Wasatch	2	---	---	Ra-226 only

TABLE 4-29
Site Name: Rifle (Old Site)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards from 40 CFR 192.32(a)
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Selenium	0.01	Upgradient	Alluvium	2	1	50	0.18
		Down gradient	Alluvium	3	1	33	0.06
		On-Site	Alluvium	6	2	33	0.016
		Upgradient	Wasatch	2	---	---	---
Silver	0.05	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
--- Standard not exceeded.

TABLE 4-30

Site Name: Rifle (Old Site)

Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum

Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Chloride	250	Upgradient	Alluvium	2	---	50	455
		Down gradient	Alluvium	2	---	---	---
		On-Site	Alluvium	6	---	---	---
		Upgradient	Wasatch	2	2	100	5700
Copper	1.0	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
Fluoride	1.4	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
Iron	0.3	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	1	17	0.44
		Upgradient	Wasatch	2	2	100	312
Manganese	0.05	Upgradient	Alluvium	2	1	50	0.80
		Down gradient	Alluvium	3	2	67	2.49
		On-Site	Alluvium	6	5	83	1.09
		Upgradient	Wasatch	2	2	100	15.4
Molybdenum	0.10	Upgradient	Alluvium	2	1	50	0.12
		Down gradient	Alluvium	3	1	33	0.18
		On-Site	Alluvium	6	2	38	0.12
		Upgradient	Wasatch	2	2	100	0.16
Nitrate 2/	44	Upgradient	Alluvium	2	1	50	19.5
		Down gradient	Alluvium	3	1	33	37.2
		On-Site	Alluvium	6	1	17	14.6
		Upgradient	Wasatch	2	---	---	---
pH 3/	6.5-8.5	Upgradient	Alluvium	2	---	---	---
		Down gradient	Alluvium	3	---	---	---
		On-Site	Alluvium	6	---	---	---
		Upgradient	Wasatch	2	1	50	9.44

TABLE 4-30

Site Name: Rifle (Old Site)
Data Evaluation: Site Water Quality Compared to U.S. EPA Standards Not Included in 40 CFR 192.32(a) plus Uranium and Molybdenum
Data Interval: 06/25/80 to 01/09/87

Constituent	Standard (mg/l) 1/	Hydraulic Flow Relationship	Formation of Completion	Number of Analyses	Number of Analyses Exceeding Standard	Percent Exceeding Standard	Maximum Value Obtained (mg/l) 1/
Sulfate	250	Upgradient	Alluvium	2	2	100	2640
		Down gradient	Alluvium	3	1	33	1300
		On-Site	Alluvium	6	6	100	814
		Upgradient	Wasatch	2	2	100	4910
Total Solids	500	Upgradient	Alluvium	2	2	100	5242
		Down gradient	Alluvium	3	2	67	2814
		On-Site	Alluvium	6	6	100	1750
		Upgradient	Wasatch	2	2	100	15000
Uranium 4/	0.044	Upgradient	Alluvium	2	1	50	0.887
		Down gradient	Alluvium	3	1	33	0.082
		On-Site	Alluvium	6	4	67	2.08
		Upgradient	Wasatch	2	---	---	---

1/ Values are reported in mg/l unless otherwise indicated.
2/ Concentrations of nitrate as nitrogen at a level of 10 mg/l is equivalent to concentration of nitrate as nitrate at a level of 44 mg/l. All analyses are reported in terms of nitrate as nitrate.
3/ pH reported in standard units.
4/ 30 pCi/l of uranium is equivalent of 0.044 mg/l, assuming the bulk of uranium is U-238. All analyses are reported as total uranium in mg/l.
--- Standard not exceeded.

4.16 CURRENT USES OF CONTAMINATED GROUND WATER

Contaminated ground water is believed to be used as drinking water at only two sites: Gunnison, Colorado, and Monument Valley, Arizona (Le87). However, because of the remoteness of some sites it is possible that sporatic use of contaminated ground water can occur, especially by individuals or families.

Concentrations of hazardous constituents and other data in ground water samples from downgradient wells at Gunnison are in Table 4-1. These same data for upgradient wells are given in Table 4-2 and for crossgradient wells in Table 4-3. The locations of these wells are shown in Figures 4-1 and 4-2. This information is from the draft environmental assessment for the Gunnison site (DOE84).

In Table 4-1, the downgradient domestic wells are identified by names (Hitt, Trainer, Rider, Tomichi, Collins, David, Deschene, Coleman, Corral, Marles, and Valco). Of these domestic wells, five of 19 samples of ground water exceeded a uranium concentration of 30 pCi/l (0.044mg/l) and one of 19 samples exceeded a selenium concentration of 0.01 mg/l. For all downgradient wells, uranium exceeded 30 pCi/l in 25 of 59 samples and selenium exceeded 0.01 mg/l in nine of 73 samples. In addition, for other hazardous constituents, cadmium concentrations exceeded 0.01 mg/l in four of 58 samples and nitrate concentrations exceeded 10 mg/l in seven of 59 samples.

In Tables 4-2 and 4-3, only three samples of ground water exceeded the drinking water standards for hazardous constituents. These three samples contained nitrate at concentrations of 22 to 35 mg/l and were collected immediately upgradient of the tailings pile.

The Gunnison ground water data indicate that uranium and sulfate have moved from the tailings area since peak concentrations are found downgradient from the tailings (DOE86). It is reasonable to suspect, therefore, that concentrations of uranium and sulfate will increase in the downgradient domestic wells as these contaminants move downgradient. Figure 4-3 depicts the uranium plume near the Gunnison pile.

At the Monument Valley site there are four residences which may be using ground water as drinking water as shown in Figure 4-4. Ground water quality at these residences is reflected by concentration levels in sampling wells 602, 610, 613, 621, and 622, where chromium and gross alpha exceed drinking water

Table 4-31 Ground-water quality - Gunnison - downgradient

Well	Date	Electrical conductivity (umho/cm)	Temp. (°C)	pH	Alkalinity (as $CaCO_3$)	Al	As	Ba	Ca	Cd	Cl	Cr	Cu	F	Fe	K
203A	10/24/83	580	11.5	7.42	282	<0.002	<0.001	0.029	121.	<0.0005	11.6	0.003	<0.001	<0.1	0.009	6.25
203B	10/25/83	400	14	6.88	264	<0.002	<0.001	0.024	75.0	<0.0005	10.1	<0.001	0.008	<0.1	0.012	5.52
204B	10/27/83	1450	14.5	6.19	188	0.190	0.002	0.043	568.	<0.0005	22	0.003	0.007	N/A	13.8	7.73
205A	10/23/83	1040	13	6.13	182	<0.002	<0.001	0.019	51.5	0.0111	5.2	<0.001	0.007	N/A	3.67	5.00
205B	10/24/83	310	14	6.95	240	<0.002	<0.001	0.169	61.0	<0.0005	11.6	<0.001	<0.001	N/A	1.64	5.01
206A	10/19/83	1710	11	5.55	145	0.157	0.004	0.057	467.	0.034	8.4	0.006	0.004	N/A	3.41	5.25
	01/31/84	N/A	8.8	6.30	110	0.028	<0.001	0.005	486.	<0.0001	13	< .0001	< .001	<0.1	6.38	5.73
	01/31/84	N/A	8.8	6.30	N/A	<0.10	<0.010	<0.010	460.	<0.001	6	<0.01	<0.02	<0.1	12	4.7
206B	10/19/82	1800	13.0	6.11	382	<0.003	<0.001	0.090	640.	0.010	12	0.004	<0.001	N/A	11.0	7.75
	02/01/84	N/A	7.0	N/A	290	0.054	<0.001	0.006	556.	<0.0001	11	<0.001	<0.001	<0.1	42.8	6.93
	02/01/84	N/A	7.0	N/A	N/A	<0.10	<0.010	<0.10	580.	<0.001	5	<0.01	<0.02	1.0	50	6.4
207A	10/17/83	1280	12.0	5.88	195	<0.003	<0.001	0.016	232.	0.007	6.0	0.002	<0.001	N/A	<0.01	1.75
	01/29/84	N/A	8.2	6.06	95	0.010	<0.001	0.006	231.	<0.0001	6.9	<0.001	<0.001	<0.1	0.24	3.30
207B	10/17/83	1920	11	5.76	195	0.013	<0.001	0.040	573.	0.017	11	0.005	0.005	N/A	101	3.03
	01/29/84	N/A	8.0	6.31	170	0.042	<0.001	0.009	589	<0.0001	9.7	<0.001	<0.001	<0.1	67.0	4.73
208	10/12/83	1435	11.0	4.74	65	0.119	<0.001	<0.002	335	<0.0005	6.8	<0.001	<0.02	<0.1	13.4	3.74
	10/13/83	1340	10.0	4.75	75	0.111	<0.001	<0.002	321	<0.0005	7.2	<0.001	<0.02	<0.1	13.6	3.26
	10/13/83	1300	11.5	5.11	58	0.106	<0.001	<0.002	324	<0.0005	8.2	0.006	<0.02	<0.1	13.6	3.02
	10/14/83	1300	11.0	5.08	56	0.113	<0.001	<0.002	331	<0.0005	5.2	<0.001	<0.02	<0.1	13.8	5.25
209A	10/17/83	1620	11	6.38	195	<0.003	<0.001	0.026	322	0.008	5.4	<0.001	<0.001	N/A	<0.01	3.00
	01/29/84	N/A	8.4	6.95	115	0.014	<0.001	0.012	413	<0.0001	8.3	<0.001	<0.001	<0.1	0.80	6.23
209B	10/17/83	2050	12	6.15	285	0.014	<0.001	0.075	599	0.008	16	0.003	0.009	N/A	55.4	4.01
	01/29/84	N/A	8.0	6.29	220	0.038	<0.001	0.013	523	<0.0001	10	<0.001	<0.001	<0.1	48.8	5.93
210A	10/23/84	1620	12	5.97	314	<0.003	<0.001	<0.002	459	0.005	9.6	0.003	0.005	<0.1	34.5	11.0
210B	10/20/83	1940	16	6.28	360	<0.003	<0.001	0.026	603	0.007	10	0.003	<0.003	N/A	0.013	9.00
211A	10/25/83	1900	12	5.89	188	0.135	0.003	0.026	457	<0.0005	13	<0.001	<0.001	<0.1	0.321	8.49
211B	10/26/83	1670	14	6.53	344	<0.02	<0.001	0.029	540	<0.0005	25	<0.001	<0.001	<0.1	13.0	7.75
212A	10/18/83	1510	10	5.49	135	<0.003	<0.001	0.023	349	0.011	5.0	0.002	<0.001	N/A	<0.001	3.75
	01/26/84	N/A	9.0	6.12	100	0.019	<0.001	0.028	293	<0.0001	9.0	<0.001	<0.001	<0.1	0.40	4.63
212B	10/18/83	2100	13.0	6.08	345	<0.003	<0.001	0.115	613	0.009	43	0.003	0.004	N/A	21.8	5.25
	01/27/84	N/A	7.1	6.48	280	0.030	<0.001	0.009	483	<0.0001	12	<0.001	<0.001	<0.1	17.6	8.18

[N/A = Not Analyzed]

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Mg	Mn	Mo	NO_3	Na	Ni	P	Pb	SO_4	Se	Si	U	V	Zn	Pb-210 (pCi/l)
203A	10/24/83	26.4	N/A	<0.001	45	41.6	<0.001	N/A	0.009	205	<0.002	1.7	0.0181	<0.004	0.005	0.6 ± 3.1
203B	10/25/83	14.6	N/A	<0.001	50	34.8	<0.001	N/A	<0.001	51.0	<0.002	3.8	0.0184	<0.004	0.003	0.3 ± 1.7
204B	10/27/83	23.1	N/A	0.058	3.5	65.5	0.002	N/A	<0.001	1480	0.007	N/A	0.116	<0.004	0.289	1.6 ± 2.2
205A	10/23/83	61.2	N/A	0.003	11.0	88.7	0.061	N/A	<0.001	24.7	0.016	N/A	0.0018	<0.004	0.012	11 ± 1.0
205B	10/24/83	11.8	N/A	0.009	4.8	33.2	0.019	N/A	<0.001	22.3	<0.002	N/A	0.0033	<0.004	0.009	3.9 ± 1.0
206A	10/19/83	86.1	N/A	0.008	2.3	109	0.015	N/A	<0.001	1720	0.036	N/A	0.0048	0.006	0.045	2.3 ± 3.6
	01/31/84	75.5	66.5	<0.001	3.1	49.9	<0.04	< 5	<0.001	1620	<0.002	7.5	0.0028	<0.004	0.021	0.0 ± 1.6
	01/31/84	72.0	77.0	<0.01	< 1	45	<0.04	N/A	0.010	1600	<0.005	20	0.005	<0.01	0.04	<1.5
206B	10/19/82	42.1	N/A	0.007	< 0.7	48.6	0.045	N/A	0.001	1500	0.030	N/A	0.917	0.007	0.320	3.6 ± 3.3
	02/01/84	36.5	9.40	<0.001	2.0	21.8	<0.04	< 5	<0.001	1520	<0.002	2.6	1.07	<0.004	0.502	0.5 ± 1.3
	02/01/84	36	9.40	<0.010	< 1.0	18.0	0.14	N/A	<0.010	1300	<0.005	N/A	1.086	<0.01	0.57	< 1.5
207A	10/17/83	64.4	N/A	<0.001	1.0	94.4	0.002	N/A	0.002	886	<0.002	N/A	0.0052	<0.004	0.014	1.0 ± 1.0
	01/29/84	58.0	24.4	<0.001	2.4	47.5	<0.04	< 5	<0.001	845	<0.002	7.5	0.0033	<0.004	0.012	2.0 ± 1.7
207B	10/17/83	30.5	N/A	0.008	1.1	43.9	0.068	N/A	<0.001	1620	0.005	N/A	0.801	<0.004	1.46	5.4 ± 1.1
	01/29/84	28.2	3.36	<0.001	2.6	16.6	<0.04	< 5	<0.001	1500	<0.002	5.4	0.986	<0.004	1.27	1.4 ± 1.0
208	10/12/83	38.4	N/A	<0.001	< 0.7	53.4	0.13	N/A	<0.001	1100	0.100	0.8	0.275	0.046	0.106	3.7 ± 1.5
	10/13/83	37.5	N/A	<0.001	1.1	53.2	0.13	N/A	<0.001	1100	0.087	0.7	0.0421	0.047	0.093	0.0 ± 0.7
	10/13/83	37.0	N/A	<0.001	1.0	50.1	0.20	N/A	<0.001	1100	0.085	1.2	0.0265	0.046	0.098	1.3 ± 1.3
	10/14/83	38.1	N/A	<0.001	< 0.7	54.2	0.18	N/A	<0.001	1100	0.085	6.4	0.0353	0.004	0.0094	1.7 ± 1.2
209A	10/17/83	91.7	N/A	0.003	1.0	96.5	0.002	N/A	0.010	1140	0.006	N/A	0.0110	0.009	0.013	1.1 ± 1.1
	01/29/84	96.8	35.5	<0.001	2.3	100	<0.04	< 5	<0.001	1600	<0.002	10.0	0.0049	<0.004	0.015	0.0 ± 1.1
209B	10/17/83	35.0	N/A	0.008	< 0.7	44.2	0.049	N/A	<0.001	1520	0.004	N/A	1.02	0.005	0.746	2.7 ± 1.1
	01/29/84	33.0	4.93	<0.001	2.1	19.3	<0.04	< 5	<0.001	1430	<0.002	12.6	0.909	<0.004	0.721	1.9 ± 2.3
210A	10/23/84	78.2	N/A	0.002	110	183	<0.001	N/A	0.009	1640	0.002	1.9	0.200	<0.004	0.054	2.4 ± 2.7
210B	10/20/83	46.8	N/A	0.006	2.3	45.1	0.051	N/A	<0.001	1540	<0.002	N/A	0.863	0.11	0.390	12 ± 2
211A	10/25/83	112	N/A	<0.001	45	128	<0.001	N/A	<0.001	1820	0.008	1.6	0.0078	<0.004	0.009	3.0 ± 2.1
211B	10/26/83	46.2	N/A	0.006	12	58.0	0.018	N/A	<0.001	1390	0.006	5.6	0.622	<0.004	0.021	4.6 ± 1.9
212A	10/18/83	78.5	N/A	0.002	1.4	92.0	<0.001	N/A	<0.001	1280	0.012	N/A	0.0061	<0.004	0.032	1.0 ± 1.1
	01/26/84	66.3	38.0	<0.001	2.3	54.3	<0.004	< 5	<0.001	1160	<0.002	6.8	0.0044	<0.004	0.016	0.7 ± 1.9
212B	10/18/83	42.6	N/A	0.007	<0.7	46.6	0.020	N/A	< 0.001	1540	0.003	N/A	1.24	<0.004	0.016	0.7 ± 1.9
	01/27/84	30.5	5.00	<0.001	2.3	25.3	<0.004	< 5	< 0.001	1180	<0.002	6.2	1.03	<0.004	0.115	0.9 ± 2.0

[N/A = Not Analyzed]

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Electrical conductivity (umho/cm)	Temp. (°C)	pH	Alkalinity (as $CaCO_3$)	Al	As	Ba	Ca	Cd	Cl	Cr	Cu	F	Fe	Hg	K
213A	10/18/83	1510	11.5	6.31	2456	<0.003	<0.001	0.047	364	0.009	8.8	0.002	<0.001	N/A	0.23	N/A	2.25
213B	10/18/83	1100	N/A	6.77	245	<0.003	<0.001	0.118	247	0.009	4.8	0.002	<0.001	N/A	0.20	N/A	5.28
214B	10/26/83	500	14	7.24	308	0.015	<0.001	0.228	129	<0.0005	23	<0.001	<0.001	<0.1	0.319	N/A	4.48
Hitt	02/02/84	N/A	14	N/A	240	0.004	<0.001	0.009	79.2	<0.0001	8.0	<0.001	<0.001	<0.1	0.91	N/A	2.55
Trainer	02/07/84	N/A	6.4	7.0	260	0.002	<0.001	0.007	129	<0.0001	11	<0.001	<0.001	<0.1	0.68	N/A	1.86
Rider	02/27/84	N/A	9.7	7.2	100	0.003	<0.001	0.002	31.0	<0.0001	2.6	<0.001	<0.001	<0.1	0.96	N/A	1.01
Tomichi	01/30/84	N/A	4.3	7.17	250	0.007	<0.001	0.009	86.6	<0.0001	12	<0.001	<0.001	<0.1	0.12	N/A	2.55
	01/30/84	N/A	4.3	7.17	N/A	<0.10	<0.010	0.13	93	<0.001	4	<0.01	<0.02	0.1	0.09	N/A	2.2
Collins	09/16/83	385	13	6.25	280	0.159	<0.001	0.069	33.3	<0.001	5.2	<0.001	<0.001	N/A	0.298	N/A	10.6
David	09/16/83	395	9.0	6.27	199	0.152	<0.001	0.026	101	<0.001	4.4	<0.001	<0.001	N/A	0.346	N/A	5.35
	11/01/82	510	13	7.48	290	<0.10	<0.010	<0.10	120	<0.005	2	<0.010	0.013	<1.0	4.6	<0.002	3
Deschene	10/11/82	350	11	7.41	N/A	<0.10	<0.010	<0.10	1	<0.005	2	<0.010	0.010	<1	<0.1	<0.002	1
	09/16/83	305	11.0	6.54	200	0.160	<0.001	0.009	66.0	<0.001	3.6	<0.001	0.028	N/A	0.292	N/A	4.60
Coleman	10/11/82	390	12	8.00	199	<0.10	<0.010	<0.10	85.0	<0.005	4	<0.010	0.047	<1	<0.1	<0.002	6
	09/15/83	540	11	6.50	230	0.168	<0.001	0.145	105	<0.001	4.2	<0.001	0.069	N/A	0.281	N/A	6.88
	02/07/84	N/A	8.8	7.25	205	0.003	<0.001	0.007	76.5	<0.0001	8.2	<0.001	<0.001	<0.1	0.06	N/A	2.92
Corral	09/16/83	340	12	6.72	250	0.186	<0.001	0.174	79.3	<0.001	4.8	<0.001	<0.001	N/A	0.267	N/A	4.80
Marks	10/07/83	610	12	6.80	260	<0.01	<0.001	0.093	100	<0.001	8.4	<0.001	<0.02	<0.1	0.56	N/A	3.13
	02/01/84	N/A	5.7	N/A	210	0.010	<0.001	0.007	88.8	<0.0001	14	<0.001	<0.001	<0.1	1.46	N/A	2.88
	02/01/84	N/A	5.7	N/A	N/A	<0.10	<0.010	0.15	84	<0.001	9	<0.01	<0.02	0.1	1.63	N/A	1.7
Valco	10/11/82	400	12	7.49	209	<0.10	<0.010	0.12	84	<0.005	6	<0.010	<0.068	<1	<0.1	<0.002	3
	09/16/83	460	10.4	6.5	260	0.176	<0.001	0.223	93.3	<0.001	8.2	<0.001	0.066	N/A	0.257	N/A	4.45
Millsite	11/01/82	345	12	7.63	190	<0.10	<0.010	0.10	76	<0.005	4	<0.010	0.093	<1	<0.1	<0.002	2
	09/16/83	780	8	7.11	250	0.134	<0.001	0.189	71.8	<0.001	7.8	<0.001	<0.001	N/A	0.237	N/A	3.95
SP-1	10/12/82	400	16	7.58	N/A	<0.10	0.015	<0.10	82	<0.005	3	<0.010	<0.010	<1	<0.1	<0.002	2
SP-3	11/01/82	600	9	7.65	N/A	<0.10	0.015	<0.10	191	<0.005	7	<0.010	0.021	<1	<0.1	<0.002	4
CSU-213	11/01/82	1950	9	7.10	N/A	<0.10	<0.010	<0.10	183	<0.005	75	<0.010	<0.010	1	45.5	<0.002	8
CSU-214	11/01/82	290	12	7.4	N/A	<0.10	0.013	N/A	69	N/A	1	N/A	N/A	<1	0.1	N/A	2

[N/A = Not Analyzed]

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Mg	Mn	Mo	NO_3	Na	Ni	P	Pb	SO_4	Se	Si	U	V	Zn	Pb-210 (pCi/l)
213A	10/18/83	61.2	N/A	0.004	<0.7	75.7	<0.001	N/A	0.007	1000	0.008	N/A	0.262	0.007	0.034	1.9 ± 1.1
213B	10/18/83	28.2	N/A	<0.001	1.0	36.0	<0.001	N/A	<0.001	504	<0.002	N/A	0.259	<0.004	0.014	1.7 ± 1.3
214B	10/26/83	18.3	N/A	0.007	2.3	38.7	0.008	N/A	<0.001	162	<0.002	1.8	0.656	<0.004	0.002	0.8 ± 2.3
Hitt	02/02/84	20.1	2.05	<0.001	2.7	13.9	<0.004	< 5	<0.001	66.3	<0.002	1.6	0.0046	<0.004	0.020	0.0 ± 1.7
Trainer	02/07/84	27.5	0.06	<0.001	<0.7	8.13	<0.04	< 5	<0.001	191	<0.002	1.3	0.0243	<0.004	0.080	1.7 ± 1.8
Rider	02/27/84	6.48	0.03	<0.001	<0.7	3.81	<0.04	< 5	<0.001	14.8	<0.002	1.4	0.0013	<0.004	0.035	0.0 ± 1.4
Tomichi	01/30/84	20.4	0.08	<0.001	2.5	10.1	<0.04	< 5	<0.0012	74.9	<0.002	6.2	0.0096	<0.004	0.096	0.0 ± 2.0
	01/30/84	20	0.07	<0.01	<1	6.5	<0.04	N/A	<0.010	73	<0.005	7	0.011	<0.01	0.13	< 1.5
Collins	09/16/83	3.1	N/A	<0.001	<0.7	94.1	0.053	N/A	<0.001	117	<0.002	N/A	0.0030	<0.004	0.034	3.5 ± 1.3
David	09/16/83	9.50	N/A	<0.001	<0.7	25.1	0.053	N/A	<0.001	16.1	<0.002	N/A	0.0493	<0.004	0.021	1.5 ± 1.0
	11/01/82	10.0	N/A	<0.05	<5	9.0	N/A	N/A	<0.010	135	<0.010	5.2	0.068	<0.05	N/A	N/A
Deschene	10/11/82	<1	N/A	<0.05	<5	122	N/A	N/A	<0.010	51	<0.010	5.6	0.030	<0.05	N/A	N/A
	09/16/83	15.6	N/A	<0.001	1.5	20.5	0.052	N/A	<0.001	61.2	<0.002	N/A	0.0424	<0.004	0.036	2.7 ± 1.7
Coleman	10/11/82	16	N/A	<0.05	<5	10	N/A	N/A	<0.010	44	<0.010	6.7	0.060	<0.005	N/A	N/A
	09/15/83	22.2	N/A	<0.001	1.3	23.4	0.072	N/A	<0.001	170	<0.002	N/A	0.0583	<0.004	0.047	1.0 ± 1.0
	02/07/84	14.4	0.43	<0.001	1.8	4.88	<0.04	< 5	<0.001	58.0	<0.002	2.4	0.0385	<0.004	0.028	1.6 ± 1.3
Corral	09/16/83	15.3	N/A	<0.001	1.3	17.2	0.042	N/A	<0.001	46.3	<0.002	N/A	0.0092	<0.004	0.046	1.6 ± 1.1
Marks	10/07/83	21.9	N/A	<0.001	1.1	12.9	0.06	< 5	<0.001	< 1	0.02	0.5	0.198	<0.004	0.061	0.0 ± 0.9
	02/01/84	22.2	0.24	<0.001	2.4	12.0	<0.04	< 5	<0.001	139	<0.002	1.4	0.0161	<0.004	0.377	0.0 ± 1.8
	02/01/84	19	0.18	<0.01	<1	6.6	<0.04	N/A	<0.010	140	<0.005	6	0.018	<0.01	0.46	< 1.5
Valco	10/11/82	18	N/A	<0.05	<5	10	N/A	N/A	<0.010	29	<0.010	7.4	0.012	<0.05	N/A	N/A
	09/16/83	19.6	N/A	<0.001	1.7	19.5	0.070	N/A	<0.001	50.5	<0.002	N/A	0.0166	<0.004	0.083	0.8 ± 2.0
Millsite	11/01/82	17	N/A	<0.05	<5	7	N/A	N/A	<0.010	22	<0.010	7.1	0.006	<0.05	N/A	N/A
	09/16/83	16.8	N/A	<0.001	1.3	16.9	0.064	N/A	<0.001	24.9	<0.002	N/A	0.0032	<0.004	0.026	1.8 ± 1.6
SP-1	10/12/82	16	N/A	<0.05	<5	7	N/A	N/A	<0.010	44	<0.010	6.6	0.044	<0.05	N/A	N/A
SP-3	11/01/82	16	N/A	<0.05	<5	11	N/A	N/A	<0.010	260	<0.010	5.0	0.148	<0.05	N/A	N/A
CSU-213	11/01/82	43	N/A	<0.05	115	22	N/A	N/A	<0.010	1647	<0.010	9.7	1.00	<0.05	N/A	N/A
CSU-214	11/01/82	11	N/A	<0.05	<5	4	N/A	N/A	N/A	15	<0.010	N/A	0.028	<0.05	N/A	N/A

[N/A = Not Analyzed]

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Electrical conductivity (umho/cm)	Temp. (°C)	pH	Alkalinity (as $CaCO_3$)	Al	As	Ba	Ca	Cd	Cl	Cr	Cu	F	Fe	K
SP-1	08/31/82	440	14	6.91	N/A	<0.1	N/A	N/A	82	N/A	3	N/A	N/A	N/A	0.03	N/A
	06/30/82	N/A	N/A	7.30	N/A	0.1	N/A	N/A	84	N/A	4	N/A	N/A	N/A	0.012	N/A
	11/00/81	N/A	N/A	N/A	N/A	<0.1	N/A	N/A	86	N/A	3	N/A	N/A	N/A	0.02	N/A
SP-2	08/31/82	1960	14	3.65	N/A	132.0	N/A	N/A	495	N/A	6	N/A	N/A	N/A	14.9	N/A
	06/30/82	N/A	N/A	3.82	N/A	71.0	N/A	N/A	461	N/A	4	N/A	N/A	N/A	4.60	N/A
	11/00/81	N/A	N/A	N/A	N/A	78.0	N/A	N/A	249	N/A	<2	N/A	N/A	N/A	7.30	N/A
SP-3	08/31/82	110	14	6.58	N/A	<0.1	N/A	N/A	248	N/A	5	N/A	N/A	N/A	0.36	N/A
	06/30/82	N/A	N/A	6.49	N/A	0.2	N/A	N/A	190	N/A	15	N/A	N/A	N/A	0.08	N/A
	11/00/81	N/A	N/A	N/A	N/A	<0.1	N/A	N/A	253	N/A	2	N/A	N/A	N/A	0.10	N/A
GUN-209	08/31/82	2100	15	6.65	N/A	0.2	N/A	N/A	588	N/A	6	N/A	N/A	N/A	0.16	N/A
	06/30/82	N/A	N/A	6.68	N/A	0.9	N/A	N/A	434	N/A	12	N/A	N/A	N/A	1.59	N/A
	11/00/81	N/A	N/A	N/A	N/A	<0.1	N/A	N/A	462	N/A	5	N/A	N/A	N/A	<0.01	N/A
GUN-212A	08/31/82	2010	15	5.85	N/A	0.3	N/A	N/A	600	N/A	4	N/A	N/A	N/A	21.4	N/A
	06/30/82	N/A	N/A	6.59	N/A	0.6	N/A	N/A	434	N/A	12	N/A	N/A	N/A	11.6	N/A
GUN-213	08/31/82	2190	15	6.24	N/A	0.3	N/A	N/A	632	N/A	4	N/A	N/A	N/A	22.4	N/A
	06/30/82	N/A	N/A	6.54	N/A	0.3	N/A	N/A	563	N/A	13	N/A	N/A	N/A	0.67	N/A
	11/00/81	N/A	N/A	N/A	N/A	0.2	N/A	N/A	597	N/A	54	N/A	N/A	N/A	0.30	N/A
GUN-214	08/31/82	400	16	6.53	N/A	0.2	N/A	N/A	76	N/A	<2	N/A	N/A	N/A	0.05	N/A
	06/30/82	N/A	N/A	6.90	N/A	0.2	N/A	N/A	93	N/A	11	N/A	N/A	N/A	0.46	N/A

[N/A = Not Analyzed]

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Mg	Mn	Mo	NO_3	Na	Ni	P	Pb	SO_4	Se	Si	U	V	Zn	Pb-210 (pCi/l)
SP-1	08/31/82	16	0.4	N/A	N/A	.6	N/A	N/A	N/A	14	<0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	17	0.03	N/A	N/A	6	N/A	N/A	N/A	34	≤0.1	N/A	N/A	N/A	N/A	N/A
	11/00/81	17	N/A	N/A	N/A	6	N/A	N/A	N/A	77	N/A	N/A	N/A	N/A	N/A	N/A
SP-2	08/31/82	82	8.63	N/A	N/A	32	N/A	N/A	N/A	780	0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	60	6.20	N/A	N/A	17	N/A	N/A	N/A	757	0.4	N/A	N/A	N/A	N/A	N/A
	11/00/81	36	N/A	N/A	N/A	9	N/A	N/A	N/A	1150	N/A	N/A	N/A	N/A	N/A	N/A
SP-3	08/31/82	21	.25	N/A	N/A	9	N/A	N/A	N/A	140	<0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	22	0.05	N/A	N/A	22	N/A	N/A	N/A	125	≤0.1	N/A	N/A	N/A	N/A	N/A
	11/00/81	28	N/A	N/A	N/A	10	N/A	N/A	N/A	562	N/A	N/A	N/A	N/A	N/A	N/A
GUN-209	08/31/82	47	.43	N/A	N/A	22	N/A	N/A	N/A	480	≤0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	40	0.74	N/A	N/A	22	N/A	N/A	N/A	422	0.1	N/A	N/A	N/A	N/A	N/A
	11/00/81	52	N/A	N/A	N/A	39	N/A	N/A	N/A	1150	N/A	N/A	N/A	N/A	N/A	N/A
GUN-212A	08/31/82	46	8.79	N/A	N/A	31	N/A	N/A	N/A	560	0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	48	9.30	N/A	N/A	34	N/A	N/A	N/A	560	0.1	N/A	N/A	N/A	N/A	N/A
GUN-213	08/31/82	39	8.16	N/A	N/A	4	N/A	N/A	N/A	480	0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	44	5.20	N/A	N/A	24	N/A	N/A	N/A	571	≤0.1	N/A	N/A	N/A	N/A	N/A
	11/00/81	50	N/A	N/A	N/A	26	N/A	N/A	N/A	1440	N/A	N/A	N/A	N/A	N/A	N/A
GUN-214	08/31/82	12	0.03	N/A	N/A	4	N/A	N/A	N/A	16	<0.1	N/A	N/A	N/A	N/A	N/A
	06/30/82	12	0.11	N/A	N/A	5	N/A	N/A	N/A	43	≤0.1	N/A	N/A	N/A	N/A	N/A

[N/A = Not Available

Table 4-31 Ground-water quality - Gunnison - downgradient (Continued)

Well	Date	Ra-226 (pCi/l)	Th-230 (pCi/l)	TDS
203A	10/24/83	0.0 ± 0.6	0.0 ± 1.9	624
203B	10/25/83	0.0 ± 0.2	0.6 ± 0.7	347
204B	10/27/83	0.9 ± 0.6	8.6 ± 2.6	2280
205A	10/23/83	0.4 ± 0.4	1.2 ± 1.8	1340
205B	10/24/83	0.1 ± 0.2	0.0 ± 0.8	256
206A	10/19/83	0.7 ± 1.0	0.4 ± 1.4	2670
	01/31/84	0.0 ± 0.2	0.0 ± 0.4	2740
	01/31/84	<1	<0.1	2700
206B	10/19/82	0.1 ± 0.3	2.8 ± 2.4	2720
	02/01/84	0.1 ± 0.2	0.6 ± 0.7	2550
	02/01/84	<1.0	<0.3	2500
207A	10/17/83	0.1 ± 0.1	2.7 ± 2.2	1420
	01/29/84	0.0 ± 0.2	0.4 ± 0.6	1410
207B	10/17/83	0.1 ± 0.2	0.8 ± 1.6	2420
	01/29/84	0.1 ± 0.2	0.6 ± 0.7	2440
208	10/12/83	0.0 ± 0.2	0.0 ± 0.5	1720
	10/13/83	0.0 ± 0.2	0.0 ± 0.5	1690
	10/13/83	0.0 ± 0.2	0.0 ± 0.5	1700
	10/14/83	0.1 ± 0.2	0.0 ± 0.5	1730
209A	10/17/83	0.2 ± 0.2	0.4 ± 1.4	1870
	01/29/84	0.0 ± 0.2	0.7 ± 0.9	2570
209B	10/17/83	0.4 ± 0.3	3.6 ± 2.6	2120
	01/29/84	0.0 ± 0.2	0.0 ± 0.4	2400
210A	10/23/84	0.0 ± 0.6	2.0 ± 2.1	2760
210B	10/20/83	0.0 ± 0.3	3.2 ± 2.5	2610
211A	10/25/83	0.0 ± 0.2	0.4 ± 0.6	3160
211B	10/26/83	0.4 ± 0.5	0.6 ± 2.0	2250
212A	10/18/83	0.1 ± 0.1	0.4 ± 1.4	1940
	01/26/84	0.0 ± 0.2	0.4 ± 0.6	1900
212B	10/18/83	0.2 ± 0.2	1.2 ± 1.8	1720
	01/27/84	0.0 ± 0.2	0.3 ± 0.6	2270

Table 4-31 Ground-water quality - Gunnison - downgradient (Concluded)

Well	Date	Ra-226 (pCi/l)	Th-230 (pCi/l)	TDS
213A	10/18/83	0.2 ± 0.2	0.4 ± 1.4	994
213B	10/18/83	0.2 ± 0.2	0.0 ± 1.5	2670
214B	10/26/83	0.2 ± 0.2	1.2 ± 2.3	459
Hitt	02/02/84	0.0 ± 0.2	0.0 ± 0.4	370
Trainer	02/07/84	0.0 ± 0.2	0.0 ± 0.4	556
Rider	02/27/84	0.0 ± 0.2	0.0 ± 0.4	119
Tomichi	01/30/84	0.0 ± 0.2	0.1 ± 0.5	401
	01/30/84	< 1	< 0.1	N/A
Collins	09/16/83	0.1 ± 0.2	0.2 ± 0.7	277
David	09/16/83	0.2 ± 0.3	0.8 ± 1.0	372
	11/01/82	< 2	N/A	N/A
Deschene	10/11/82	< 2	N/A	N/A
	09/16/83	0.5 ± 0.4	0.8 ± 1.0	302
Coleman	10/11/82	< 2	N/A	N/A
	09/15/83	0.0 ± 0.2	0.8 ± 0.9	481
	02/07/84	0.2 ± 0.3	0.0 ± 0.4	304
Corral	09/16/83	0.1 ± 0.2	1.2 ± 1.0	288
Marks	10/07/83	0.3 ± 0.3	0.9 ± 1.1	500
	02/01/84	0.0 ± 0.2	0.2 ± 0.5	450
	02/01/84	< 1	< 0.1	400
Valco	10/11/82	< 2	N/A	N/A
	09/16/83	0.0 ± 0.2	1.0 ± 0.9	351
Mill site	11/01/82	< 2	N/A	N/A
	09/16/83	0.0 ± 0.2	0.7 ± 0.8	296
SP-1	10/12/82	< 2	N/A	N/A
SP-3	11/01/82	< 2	N/A	N/A
CSU-213	11/01/82	< 2	N/A	N/A
CSU-214	11/01/82	< 2	N/A	N/A

All measurements as mg/l unless otherwise stated.

N/A = Not analyzed.

Table 4-32 Ground-water quality - Gunnison - upgradient

Well	Date	Electrical conductivity (umho/cm)	Temp. (°C)	pH	Alkalinity (as $CaCO_3$)	Al	As	Ba	Ca	Cd	Cl	Cr	Cu	F	Fe	Hg	K
201A	10/23/83	330	12	7.57	216	<0.002	<0.001	0.021	58.0	<0.0005	8.0	<0.001	0.006	<0.1	0.011	N/A	5.25
201B	10/21/83	380	14.5	7.11	254	<0.003	<0.001	0.028	69.5	0.005	9.4	0.003	<0.001	<0.1	0.02	N/A	3.69
202A	10/19/83	350	11.5	7.0	240	<0.003	<0.001	0.070	85.0	0.008	12	<0.001	<0.001	<0.1	0.27	N/A	1.85
202B	10/21/83	375	14	7.1	245	<0.003	<0.001	0.120	84.9	0.006	11	<0.001	<0.001	<0.1	2.80	N/A	3.38
Weaver	02/07/84	N/A	8.3	7.45	215	0.003	<0.001	0.005	59.8	<0.0001	7.8	<0.001	<0.001	<0.1	0.17	N/A	1.30
Cooper	02/06/84	N/A	7.5	7.2	130	0.005	<0.001	0.005	35.3	<0.0001	14	<0.001	<0.001	<0.1	0.38	N/A	2.38
Bratton	07/27/84	N/A	7.0	7.4	300	0.006	<0.001	0.002	70.3	<0.0001	12.6	<0.001	<0.001	<0.1	0.05	N/A	14.0
City	11/01/82	315	12	7.55	N/A	<0.10	<0.010	N/A	76	<0.005	2	<0.010	0.013	<1	0.6	<0.002	4
	09/15/83	355	12.0	6.5	240	0.147	<0.001	0.270	70.8	<0.001	3.0	<0.001	<0.001	N/A	0.263	N/A	5.05
City #9	02/27/84	N/A	6.9	7.4	220	0.002	<0.001	0.002	64.3	<0.0001	5.5	<0.001	<0.001	<0.1	0.11	N/A	1.38
Woods	11/01/82	280	15	7.26	N/A	<0.10	<0.010	N/A	55	N/A	2	N/A	N/A	<1	2.7	N/A	3
	09/16/83	310	14.8	6.68	200	0.143	<0.001	0.233	61.0	<0.001	4.8	<0.001	0.046	N/A	0.254	N/A	7.33
Singer	11/01/82	330	14	7.86	N/A	<0.10	<0.010	0.18	70	N/A	1	N/A	N/A	<1	3.3	N/A	1
	09/16/83	350	12	6.62	290	0.150	<0.001	0.275	76.3	<0.001	5.0	<0.001	<0.001	N/A	0.277	N/A	7.25

[N/A = Not Analyzed

Table 4-32 Ground-water quality - Gunnison - upgradient (Continued)

Well	Date	Mg	Mn	Mo	NO_3	Na	Ni	P	Pb	SO_4	Se	Si	U	V	Zn	Pb-210 (pCi/l)
201A	10/23/83	12.5	N/A	0.004	35	39.4	0.003	N/A	<0.001	24.7	<0.002	5.6	0.0062	<0.004	0.011	2.0 ± 0.8
201B	10/21/83	13.9	N/A	<0.001	25	9.22	<0.001	N/A	<0.001	49.5	<0.002	5.1	0.0038	<0.004	0.005	2.7 ± 2.6
202A	10/19/83	16.8	N/A	0.003	22	6.87	<0.001	N/A	<0.001	31.2	<0.002	0.5	0.0018	<0.004	0.014	3.0 ± 3.4
202B	10/21/83	15.8	N/A	0.003	3.1	7.49	<0.001	N/A	<0.001	28.1	<0.002	5.7	0.0063	<0.004	0.012	1.2 ± 2.2
Weaver	02/07/84	13.8	N/A	<0.001	2.0	6.78	<0.04	< 5	<0.001	9.9	<0.002	0.6	0.0020	<0.004	0.047	0.0 ± 1.6
Cooper	02/06/84	10.3	0.23	<0.001	1.9	14.9	<0.04	< 5	<0.001	16.1	<0.002	1.6	0.0032	<0.004	0.065	0.2 ± 1.6
Bratton	07/27/84	26.3	0.02	<0.001	1.7	19.3	<0.04	< 5	<0.001	36.2	<0.002	5.7	0.0085	<0.004	0.044	0.3 ± 1.0
City	11/01/82	14	N/A	<0.05	< 5	6	N/A	N/A	<0.010	15	<0.010	8.2	0.003	<0.05	N/A	N/A
	09/15/83	14.1	N/A	<0.001	1.1	15.8	0.071	N/A	<0.001	43.8	<0.002	N/A	0.0023	<0.004	0.017	3.3 ± 2.3
City #9	02/27/84	13.0	0.03	<0.001	< 0.7	3.83	<0.04	< 5	<0.001	16.5	<0.002	1.2	0.0021	<0.004	<0.005	0.5 ± 1.1
Woods	11/01/82	12	N/A	<0.05	< 5	6	N/A	N/A	N/A	11	<0.010	N/A	0.003	<0.05	N/A	N/A
	09/16/83	14.3	N/A	<0.001	< 0.7	18.1	0.037	N/A	<0.001	11.4	<0.002	N/A	0.0078	<0.004	0.022	3.1 ± 2.0
Singer	11/01/82	14	N/A	<0.05	< 5	5	N/A	N/A	N/A	15	<0.010	N/A	0.003	<0.05	N/A	N/A
	09/16/83	15.0	N/A	<0.001	1.5	16.2	0.043	N/A	0.012	19.5	<0.002	N/A	0.0039	<0.004	0.023	3.3 ± 0.8

[N/A = Not Analyzed]

Table 4-32 Ground-water quality - Gunnison - upgradient (Concluded)

Well	Date	Ra-226 (pCi/l)	Th-230 (pCi/l)	TDS
201A	10/23/83	0.0 ± 0.2	0.0 ± 0.8	291
201B	10/21/83	0.4 ± 0.4	2.4 ± 2.2	381
202A	10/19/83	0.1 ± 0.2	0.0 ± 1.4	345
202B	10/21/83	0.0 ± 0.3	0.8 ± 1.6	359
Weaver	02/07/84	0.0 ± 0.2	0.1 ± 0.5	262
Cooper	02/06/84	0.0 ± 0.2	0.0 ± 0.9	199
Bratton	07/27/84	0.0 ± 0.2	0.0 ± 0.4	401
City	11/01/82	< 2	N/A	N/A
	09/15/83	0.8 ± 0.5	0.1 ± 0.7	262
City #9	02/27/84	0.0 ± 0.2	0.0 ± 0.5	246
Woods	11/01/82	< 2	N/A	N/A
	09/16/83	0.4 ± 0.4	0.0 ± 0.6	196
Singer	11/01/82	< 2	N/A	N/A
	09/16/83	0.3 ± 0.3	0.5 ± 0.8	282

N/A = Not analyzed.

Table 4-33 Ground-water quality - Gunnison - crossgradient

Well	Date	Electrical conductivity (umho/cm)	Temp. (°C)	Eh (mV)	pH	Alkalinity (as $CaCO_3$)	Al	As	Ba	Ca	Cd	Cl	Cr	Cu	F	Fe	Hg	K
Tuttle	11/01/82	180	13.5	N/A	7.68	68	<0.10	<0.010	N/A	< 1	N/A	1	N/A	N/A	<1	0.1	N/A	< 1
	10/26/83	162	13	162	7.03	118	0.007	<0.001	0.036	24.0	<0.0005	3.8	<0.001	0.006	<0.1	0.652	N/A	2.75
Reid	11/01/82	180	11	N/A	7.60	N/A	<0.10	<0.010	N/A	36	N/A	1	N/A	N/A	<1	0.9	N/A	1
Hatcher	10/06/83	160	10	N/A	6.8	145	<0.01	<0.001	0.024	33.5	<0.001	1.6	<0.001	<0.02	<0.1	0.41	N/A	3.45
Sjoberg	10/06/83	155	10	N/A	6.81	115	<0.01	<0.001	0.017	32.3	<0.001	1.6	<0.001	<0.002	<0.1	0.57	N/A	2.73
	02/08/84	N/A	7.2	N/A	7.17	100	0.001	<0.001	0.008	31.8	<0.0001	5.9	<0.001	<0.001	<0.1	0.77	N/A	1.14
Wallace	10/06/83	290	10	N/A	7.05	230	<0.01	<0.001	0.150	62.5	<0.001	8.2	<0.001	<0.02	<0.1	9.66	N/A	5.90
	02/08/84	N/A	6.0	N/A	7.0	205	0.002	<0.001	0.009	62.7	<0.0001	7.5	<0.001	<0.001	<0.1	2.03	N/A	2.63

Well	Date	Mg	Mn	Mo	NO_3	Na	Ni	P	Pb	SO_4	Se	Si	U	V	Zn	Pb-210 (pCi/l)
Tuttle	11/01/82	<1	N/A	<0.05	<5	55	N/A	N/A	N/A	7	<0.010	N/A	<0.001	<0.05	N/A	N/A
	10/26/83	6.33	N/A	0.003	6.1	N/A	0.003	N/A	<0.001	21.4	<0.002	1.0	0.0006	<0.004	0.013	0.2 ± 1.3
Reid	11/01/82	8	N/A	<0.05	<5	55	N/A	N/A	N/A	7	<0.010	N/A	<0.001	<0.05	N/A	N/A
Hatcher	10/06/83	7.30	N/A	<0.001	1.0	12.3	0.09	< 5	<0.001	<1	<0.01	4.8	0.0018	<0.004	0.024	0.0 ± 0.9
Sjoberg	10/06/83	6.20	N/A	<0.001	1.2	11.9	0.12	< 5	<0.001	<1	<0.01	1.4	0.0009	<0.004	0.053	0.0 ± 0.8
	02/08/84	6.68	1.02	<0.001	<0.7	4.60	<0.04	< 5	<0.001	14.8	<0.002	3.8	0.0011	<0.004	0.010	0.8 ± 0.7
Wallace	10/06/83	13.6	N/A	<0.001	1.1	17.8	0.15	< 5	<0.001	<1	<0.01	1.8	0.0025	<0.004	0.014	0.0 ± 0.9
	02/08/84	13.4	4.16	<0.001	<0.7	6.21	<0.04	< 5	<0.001	21.4	<0.002	2.6	<0.0029	<0.004	0.022	0.9 ± 0.9

[N/A = Not Analyzed]

Table 4-33 Ground-water quality - Gunnison - crossgradient (Concluded)

Well	Date	Po-210 (pCi/l)	Ra-226 (pCi/l)	Ra-228 (pCi/l)	Th-230 (pCi/l)	TDS
Tuttle	11/01/82	N/A	< 2	N/A	N/A	N/A
	10/26/83	N/A	0.3 ± 0.3	N/A	2.5 ± 1.4	72.0
Reid	11/01/82	N/A	< 2	N/A	N/A	N/A
Hatcher	10/06/83	N/A	0.3 ± 0.3	N/A	0.2 ± 0.9	117
Sjoberg	10/06/83	N/A	0.0 ± 0.2	N/A	0.4 ± 0.6	112
	02/08/84	N/A	0.1 ± 0.2	N/A	0.2 ± 0.9	190
Wallace	10/06/83	N/A	0.5 ± 0.3	N/A	0.8 ± 1.1	281
	02/08/84	N/A	0.4 ± 0.3	N/A	0.0 ± 0.4	246

All measurements as mg/l unless otherwise stated.
N/A = Not analyzed.

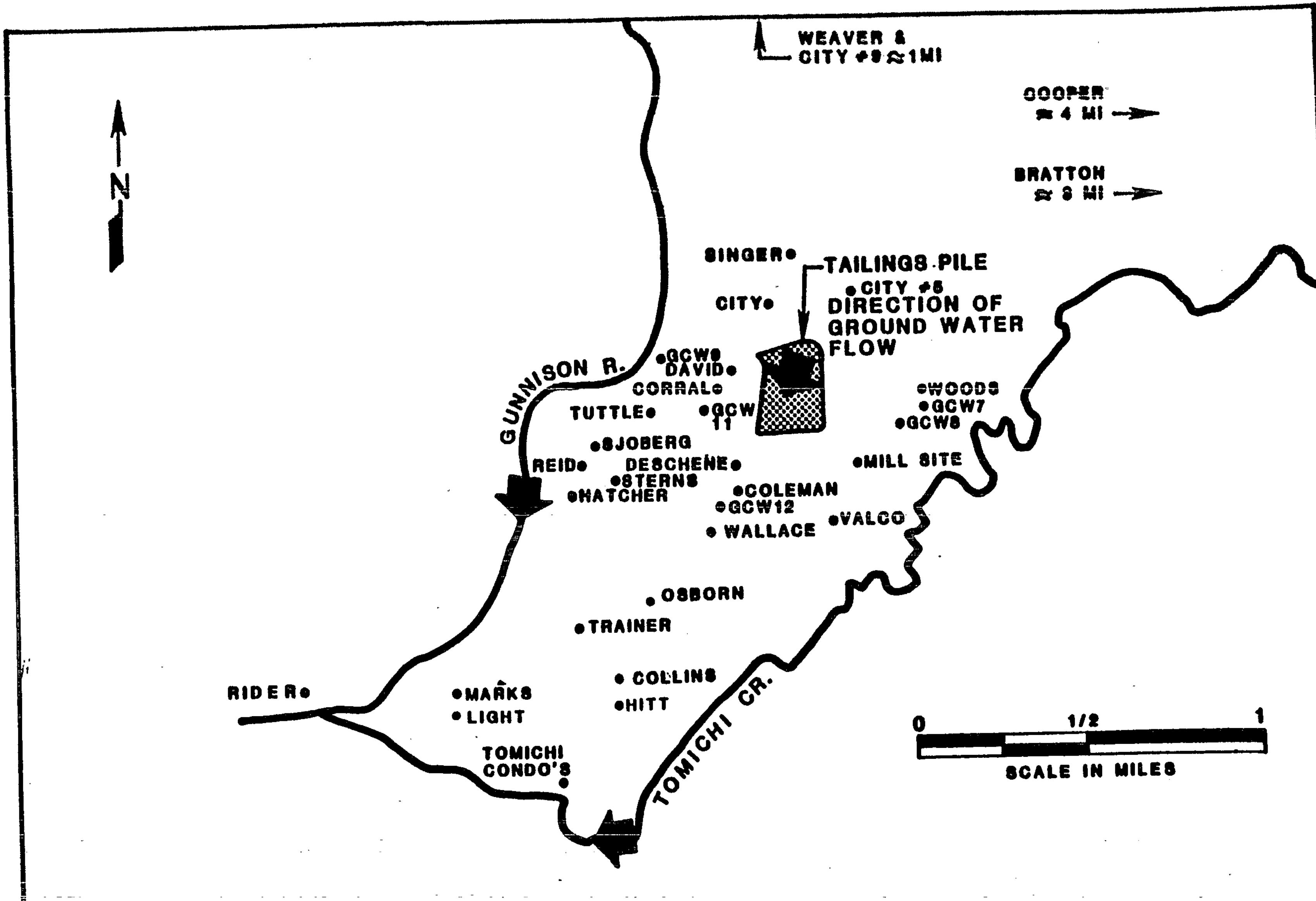


FIGURE 4-1
APPROXIMATE LOCATION OF DOMESTIC WELLS SAMPLED AT GUNNISON

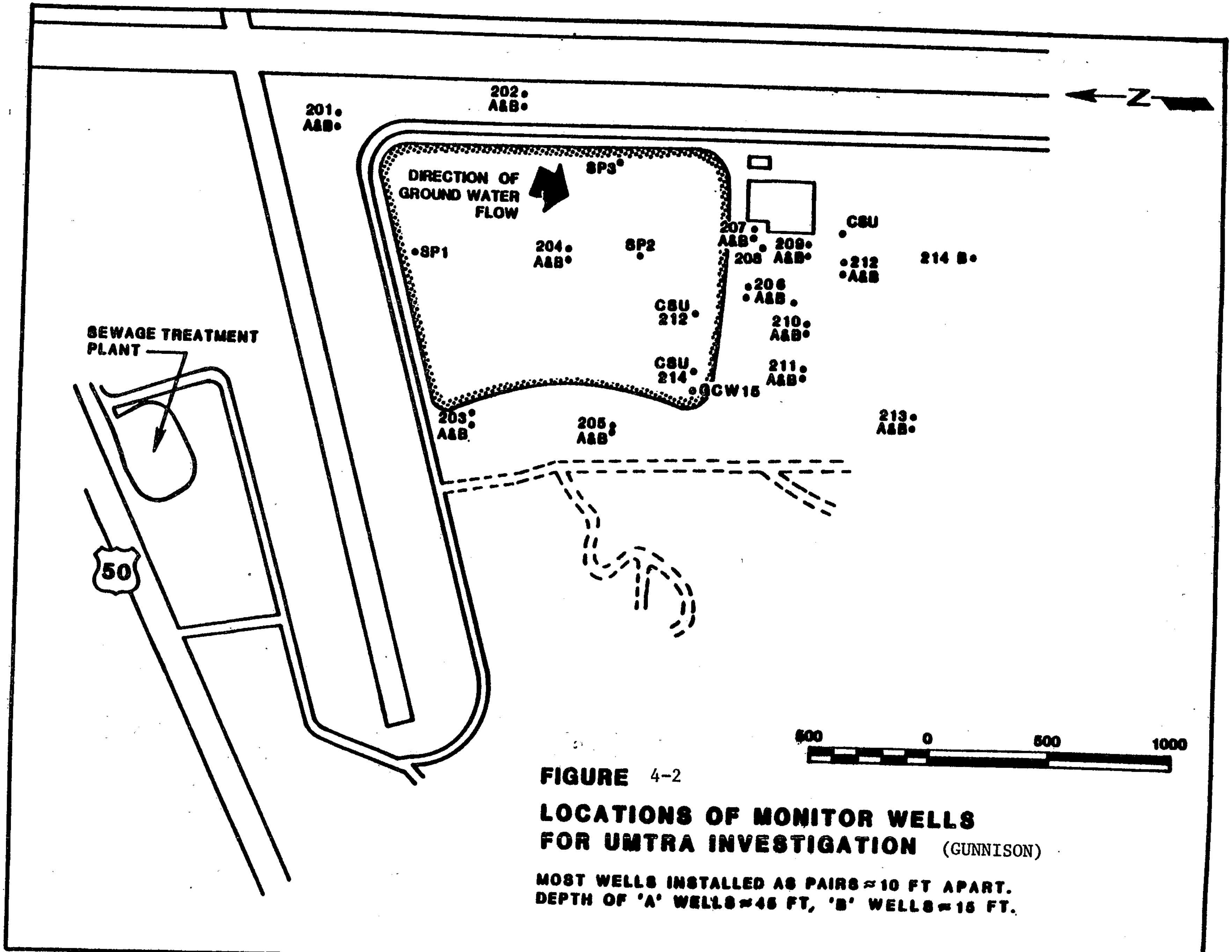


FIGURE 4-2

LOCATIONS OF MONITOR WELLS FOR UMTRA INVESTIGATION (GUNNISON)

MOST WELLS INSTALLED AS PAIRS ≈ 10 FT APART.
DEPTH OF 'A' WELLS ≈ 45 FT, 'B' WELLS ≈ 15 FT.

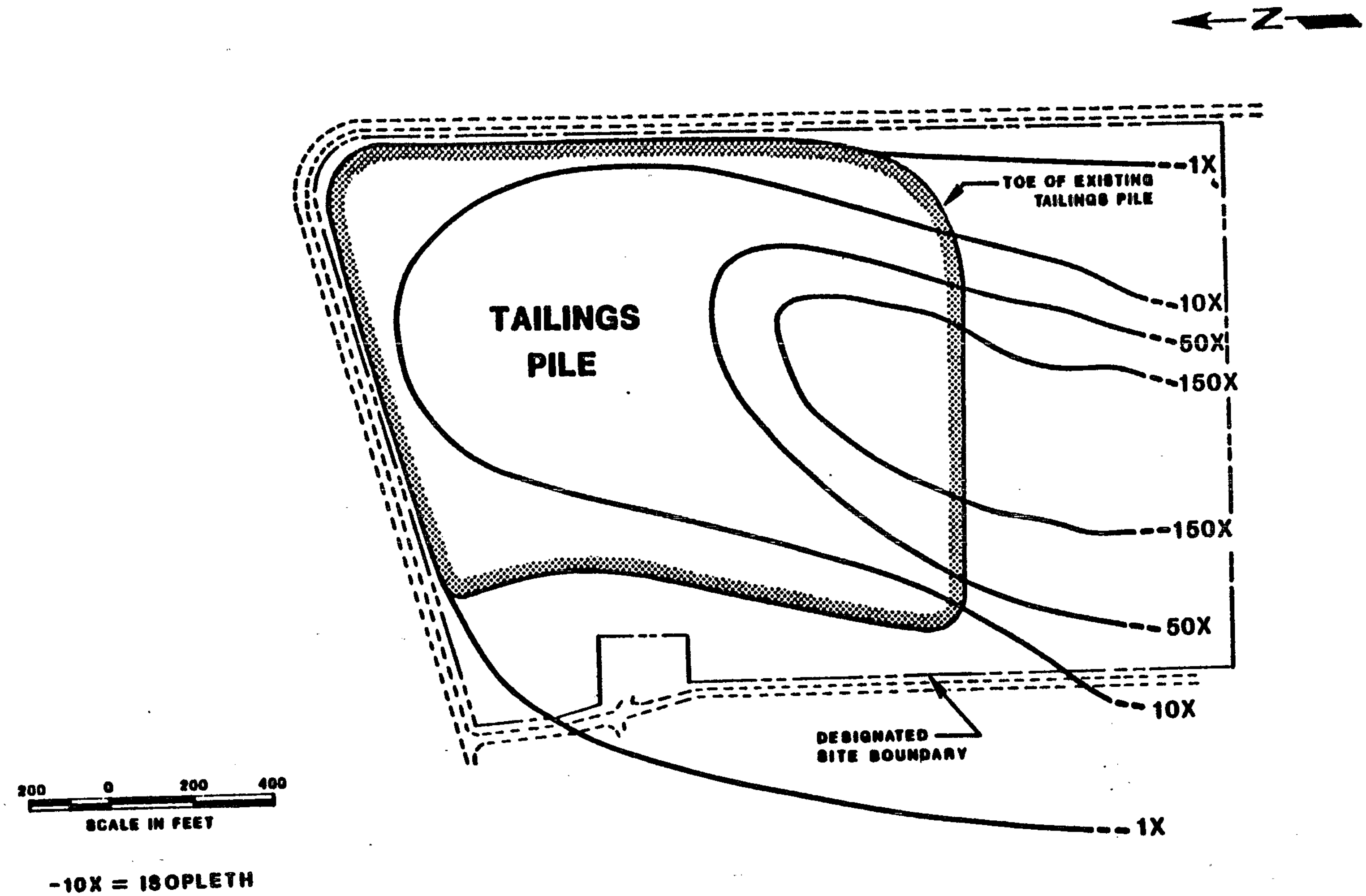


FIGURE 4-3
URANIUM PLUME NEAR PILE (GUNNISON)
U AS MULTIPLE OF HIGHEST BACKGROUND CONCENTRATION (0.008 mg/l)
DATA: 83 SAMPLES FROM 48 WELLS

standards at 622 and 610, respectively, as shown in Table 4-4. Also, the sulfate concentration is elevated at well 622.

Background water quality is shown in Table 4-5 for the alluvial aquifer at Monument Valley and in Table 4-6 for the Shinarump and DeChelly Sandstone aquifers. Figure 4-5 illustrates the sulphate plume at Monument Valley; Figure 4-6, the nitrate plume; and Figure 4-7, the uranium plume. The locations of the four residences are shown in each figure.

4.17 ORGANIC CONTAMINANTS IN GROUND WATER

Few data are available regarding organic contaminants in ground water. The NRC is conducting a program of sampling liquids in uranium mill tailings impoundments. This program is to establish a data base for hazardous constituents (40 CFR 261 Appendix VIII) in the tailings (Sm87).

The laboratory analyses performed on these tailings water samples indicate positively if any of 150 constituents are present in the tailings solution. These constituents include 54 general chemistry (anions, cations, metals) 12 volatile organic groups, 81 semivolatile groups, and three radionuclides. None of the organics have been found in the tailings solutions that were tested from nine tailings impoundments by the NRC. The elemental forms of 15 hazardous constituents were identified. These organic groups and the 15 hazardous constituents that tested postive are listed in Table 4-7.

In uranium milling, uranium has been recovered from leach liquors by three methods: solvent extraction, ion exchange, and precipitation. The solvent extraction method was used to produce 43% of total uranium production in 1976 and a solvent extraction/ion exchange combination was used to produce 18% the same year (NUREG80). Two processes, the Dapex and the Amex, are extensively used. The Dapex process uses a 4% solution of di(2-ethylhexyl) phosphoric acid (EHPA) in kerosene with tributyl phosphate added as a modifier. The Amex process uses a 6% solution of tertiary amine, such as alinine-336, in kerosene with isodecanol added as a modifier.

Early work in solvent extraction was reviewed by Flagg (Fl61). In the early 1940's, diethyl ether was used to purify uranium in the first large scale application of solvent extraction in hydrometallurgy. Flagg groups the organic extractants into organophosphorous compounds, as used in the Dapex process, and

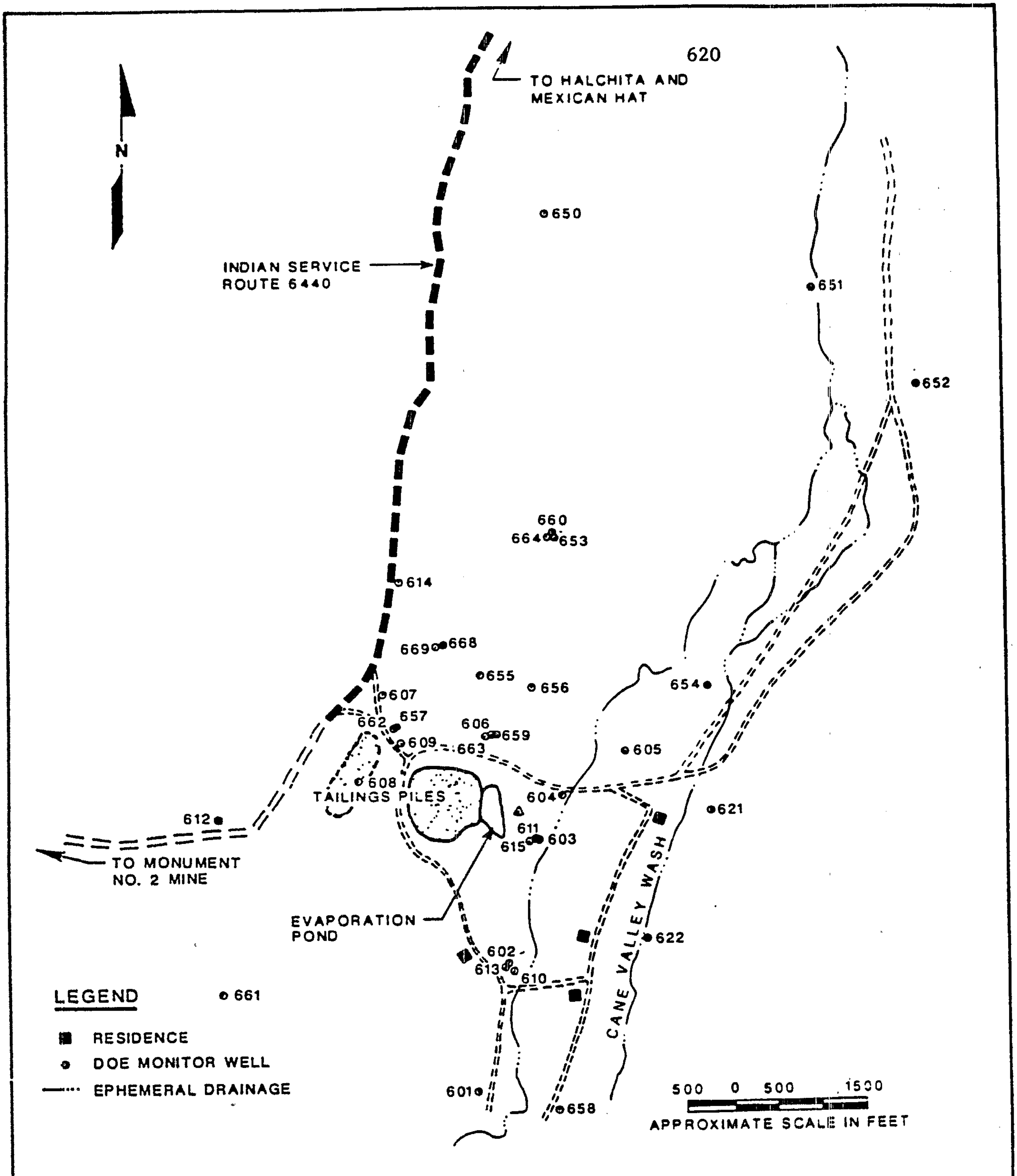


FIGURE 4-4 DOE MONITOR WELL LOCATIONS, MONUMENT VALLEY SITE

Table 4-34 Exceedence of water-quality standards at Monument Valley

	EPA primary standard[a]	EPA secondary standard[a]	Exceeded at
Arsenic	0.05		none
Barium	1.0		none
Cadmium	0.01		none
Chloride		250.0	none
Chromium	0.05		614, 622
Copper		1.0	none
Gross alpha[b,c]	15		606, 610, 614, 657, 662, 620,
Iron		0.3	614, 610
Lead	0.05		none
Manganese		0.05	603, 605, 606, 610, 620, 621, 622, 650, 651, 654, 659, 660, 655, 662, 657, 664
Mercury	0.002		none
Nitrate (as N)	10.0		606, 655, 656
pH[d]	6.5-8.5		620, 622, 650, 660, 663, 668, 661
Ra-226 + 228[b]	5.0		none
Selenium	0.01		none
Silver	0.05		none
Sulfate		250.0	605, 606, 622, 653, 655, 656, 662, 669
Total dissolved solids		500.0	605, 606, 614, 617, 620, 622, 657
Uranium[e]	0.015		606, 614, 620, 655, 657, 662
Zinc		5.0	none

[a]Milligrams per liter (mg/l) unless otherwise noted.
[b]Picocuries per liter.
[c]Reported values of gross alpha may be erroneous at TDS levels above 500 mg/l.
[d]Standard units.
[e]Health advisory level (Cothern et al., 1983).

Table 4-35 Background water quality in alluvial aquifer, Monument Valley site

Constituent	Observed concentration range[a]	No. of analyses	Mean[a]	Two standard deviations[a]	Background concentration range[a]
Alkalinity[a]	196-293	6	231	79	152-310
Aluminum	0.2-0.8	6	0.48	0.63	<0.1-1.11
Ammonium	<0.1-0.52	6	0.16	0.39	<0.1-0.55
Antimony	<0.003-0.004	6	<0.003	0.002	<0.003-0.004
Arsenic	<0.01	6	<0.01	0.0	<0.01
Barium	<0.1-0.3	6	0.16	0.25	<0.1-0.41
Boron	0.2-0.8	6	0.35	0.47	<0.1-0.82
Bromide	<0.01	3	<0.01	0.0	<0.01
Cadmium	<0.001	6	<0.001	0.0	<0.001
Calcium	18.0-35.5	6	26.6	14.0	12.6-40.6
Chloride	10.0-27.0	6	17.7	12.4	5.3-30.0
Chromium	<0.01-0.04	6	0.02	0.03	<0.01-0.05
Cobalt	<0.05	6	<0.05	0.0	<0.05
Copper	<0.02-0.03	6	<0.02	0.0	<0.02-0.04
Cyanide	<0.01	6	<0.01	0.0	<0.01
Fluoride	0.20-0.90	6	0.53	0.47	0.07-1.0
Gross alpha[b]	1.2-7.6	6	4.2	4.3	<0.2-8.5
Gross beta[b]	<1.0-20.0	6	5.5	14.4	4.0-19.8
Iron	<0.03-0.18	6	0.07	0.12	<0.03-0.19
Lead	<0.01	6	<0.01	0.0	<0.01
Magnesium	17.9-31.2	6	23.9	11.2	12.7-35.1
Manganese	<0.01-0.02	6	<0.01	0.01	<0.01-0.02
Mercury	<0.0002	6	<0.002	0.0	<0.0002
Molybdenum	<0.01-0.11	6	0.04	0.09	<0.01-0.14
Nickel	<0.04-0.13	6	0.06	0.09	<0.04-0.14
Nitrate	3.0-22.2	6	9.5	13.2	<0.1-22.7
Nitrite	<0.10-0.99	5	0.29	0.82	<0.10-1.10
Nitrate & Nitrite (as N)	2.1-5.0	3	3.1	3.2	<0.1-6.4
Total organic carbon	1.3-79.0	6	43.2	49.6	<1.0-92.8
Lead-210[b]	<1.5-5.8(±1.4)	6	1.6	4.3	<1.5-5.9
pH	7.50-8.17	6	7.76	0.60	7.16-8.32
Phosphate	<0.1-0.2	6	<0.1	0.1	<0.1-0.2
Polonium-210[b]	<1.0	6	<1.0	0.7	<1.0
Potassium	0.76-2.19	6	1.53	1.37	0.16-2.90
Radium-226[b]	<1.0(±0.3)	6	<1.0	0.6	<1.0
Radium-228[b]	<1.0(±1.3)	6	<1.0	0.1	<1.0
Selenium	<0.005	6	<0.005	0.0	<0.005
Silica	5.0-33.0	5	16.2	21.2	<2.0-37.4
Silver	<0.01	6	<0.01	0.0	<0.01
Sodium	34.2-150.0	6	94.6	91.1	3.5-185.7

Table 4-35 Background water quality in alluvial aquifer, Monument Valley site (Concluded)

Constituent	Observed concentration range[a]	No. of analyses	Mean[a]	Two standard deviations[a]	Background concentration range[a]
Strontium	<0.10	6	<0.10	0.0	<0.10
Sulfate	55.8-158.0	6	113.0	90.5	22.5-203.5
Sulfide	<0.10	6	<0.10	0.05	<0.10
Thorium-230[b]	0.0-6.3(±0.7)	6	1.2	5.03	<1.0-6.2
Tin	<0.005	6	<0.005	0.0	<0.005
Total dissolved solids	294.0-626.0	6	454.5	253.2	201.3-707.7
Uranium	<0.003-0.0054	6	0.0034	0.0024	<0.003-0.0059
Vanadium	<0.01-0.70	6	0.30	0.66	<0.01-0.97
Zinc	<0.005-1.6	6	0.5	1.4	<0.005-1.8

[a]In mg/l unless otherwise noted.
[b]For radionuclides, observed range plus analytical error is shown as the background range, in picocuries per liter.

Table 4-36 Background water quality, Shinarump and DeChelly Sandstone aquifers at Monument Valley

Constituent	Concentration in Shinarump[a]	Concentration in DeChelly[a]
Alkalinity (as $CaCO_3$)	202-220	97-198
Aluminum	0.20-0.80	0.30-0.80
Ammonium	<0.10-0.26	<0.10
Antimony	<0.003-0.005	<0.003-0.004
Arsenic	<0.01	<0.01
Barium	<0.10-0.20	<0.10-0.20
Boron	0.10-0.50	0.10-0.90
Bromide	<0.01	<0.01
Cadmium	<0.001	<0.001
Calcium	3.0-29.2	6.34-31.7
Chloride	7.0-15.0	5.0-10.0
Chromium	<0.01-0.02	<0.01-0.04
Cobalt	<0.05	<0.05-0.06
Conductance[b]	400-700	210-550
Copper	<0.02	<0.02
Cyanide	<0.01	<0.01
Fluoride	0.20-0.80	0.20-0.60
Gross alpha[c]	0.50-22.0	1.0-6.10
Gross beta[c]	3.2-12.0	4.4-8.0
Iron	<0.03-0.33	<0.03-0.10
Lead	<0.01	<0.01
Magnesium	15.1-20.3	17.0-28.0
Manganese	<0.01-0.10	<0.01-0.05
Mercury	<0.0002	<0.0002
Molybdenum	<0.01-0.22	<0.01-0.18
Nickel	<0.04-0.11	<0.04-0.11
Nitrate	0.5-13.29	1.0-22.0
Nitrite	<0.10-1.65	<0.10-1.65
Nitrate & Nitrite (as N)	0.3-3.3	1.3-2.5
Organic carbon	42.0-51.0	22.0-53.0
Lead-210[c]	0.1-3.7	0.0-1.2
pH[d]	7.1-8.4	7.4-9.4
Phosphate (as P)	<0.10-0.60	<0.10-0.30
Polonium-210[c]	0.00-0.60	0.00-0.40
Potassium	1.41-3.99	1.55-5.25
Radium-226[c]	0.10-8.6	0.00-0.30
Radium-228[c]	0.00-0.50	0.00-0.60
Selenium	<0.005	<0.005
Silica	9.0-13.0	5.0-11.0
Silver	<0.01	<0.01
Sodium	73.7-94.9	6.4-50.2
Strontium	<0.10	<0.10
Sulfate	72.0-128.0	13.2-62.1

Table 4-36 Background water quality, Shinarump and DeChelly Sandstone aquifers (Concluded)

Constituent	Concentration in Shinarump[a]	Concentration in DeChelly[a]
Sulfide	<0.10	<0.10
Temperature °C	13.0-20.0	15.0-19.0
Thorium-230[c]	0.00-0.20	0.00-0.40
Tin	<0.005	<0.005
Total dissolved solids	348.0-418.0	158.0-321.0
Total organic halogens	<0.003-0.007	<0.003
Uranium	0.002-0.008	0.001-0.008
Vanadium	<0.01-0.60	<0.01-0.80
Zinc	<0.005-0.09	<0.010-1.26

[a]As mg/l unless otherwise noted.
[b]umhos/cm^2.
[c]Picocuries per liter.
[d]Standard units.

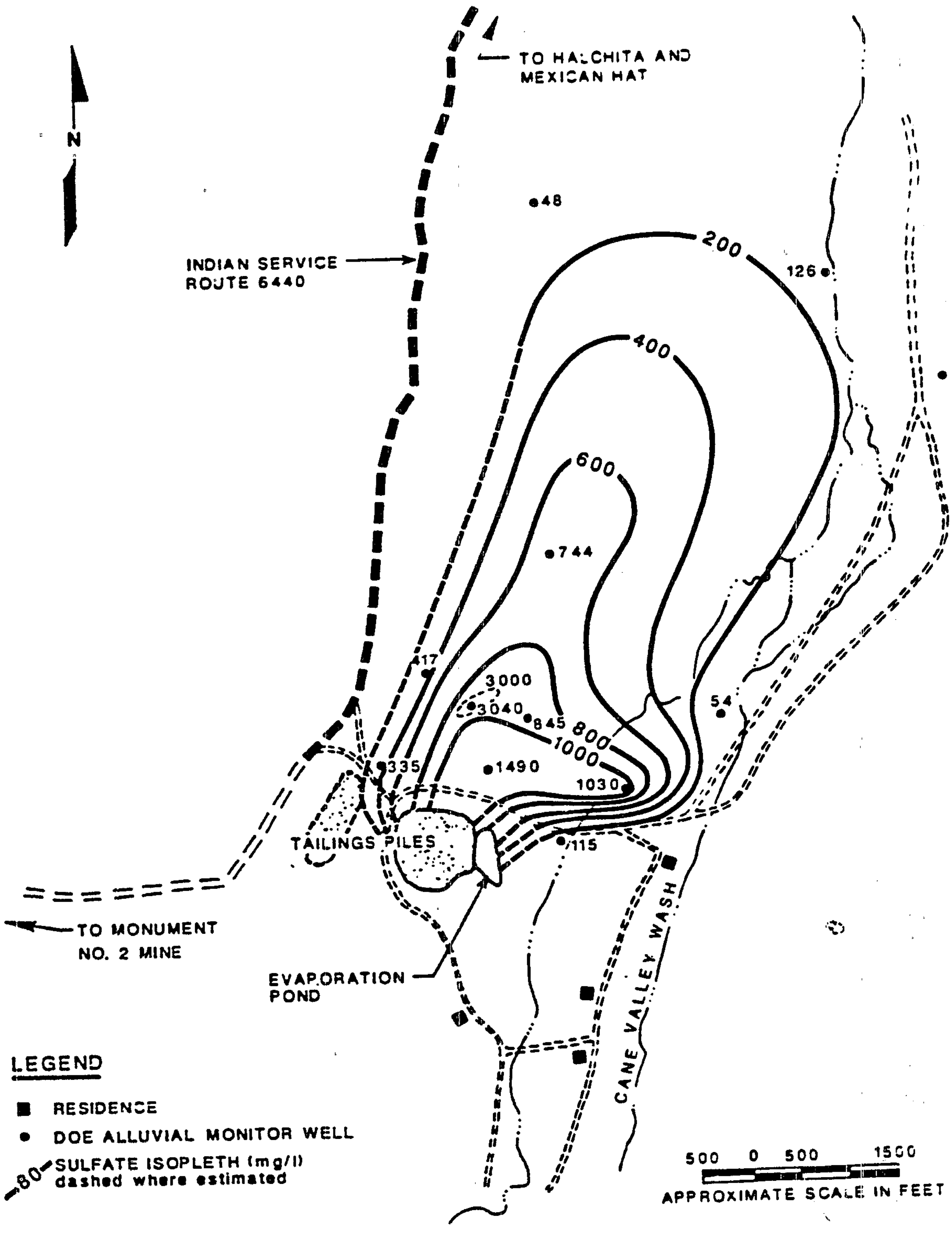


FIGURE 4-5 SULFATE PLUME, MONUMENT VALLEY SITE

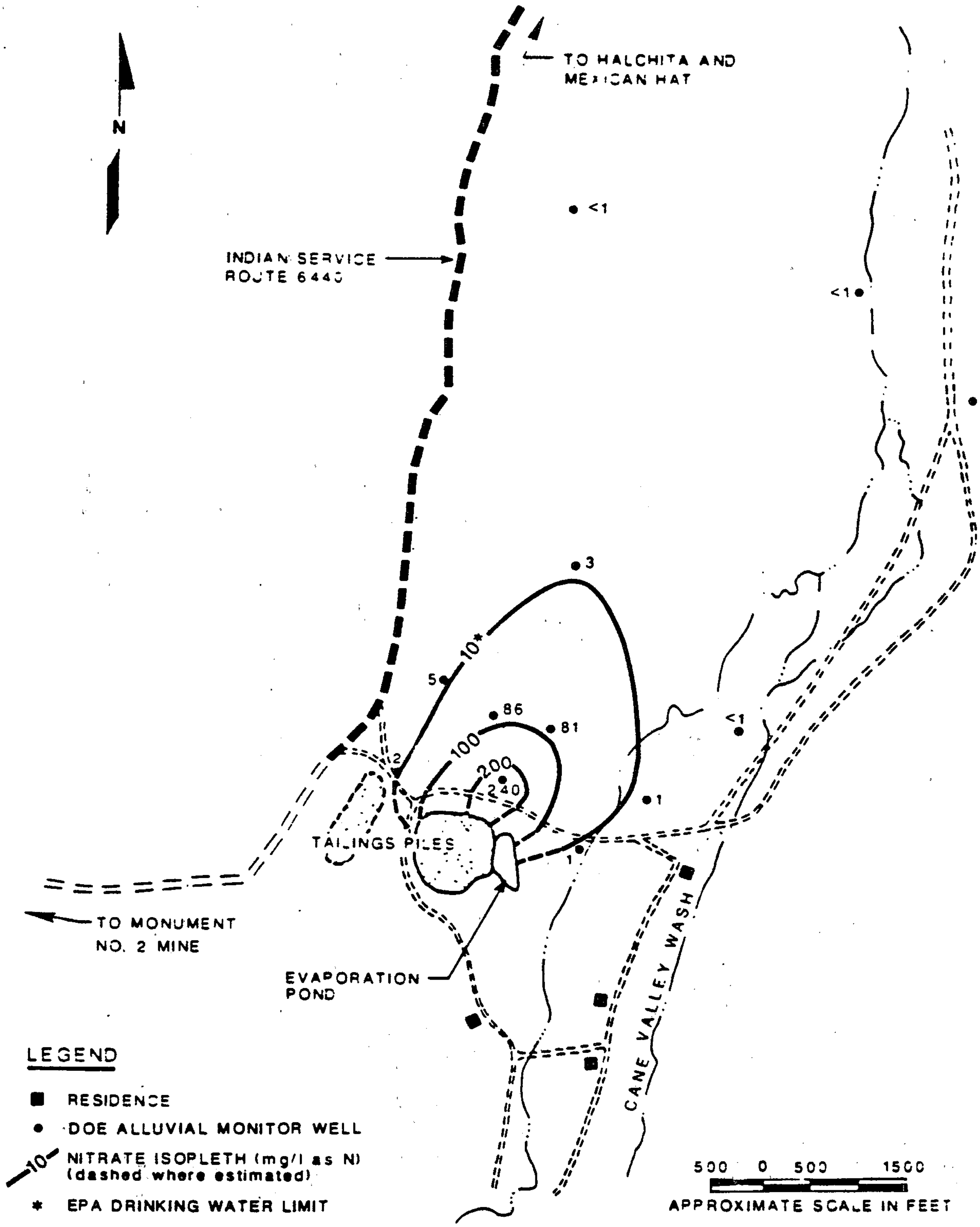


FIGURE 4-6 NITRATE PLUME, MONUMENT VALLEY SITE

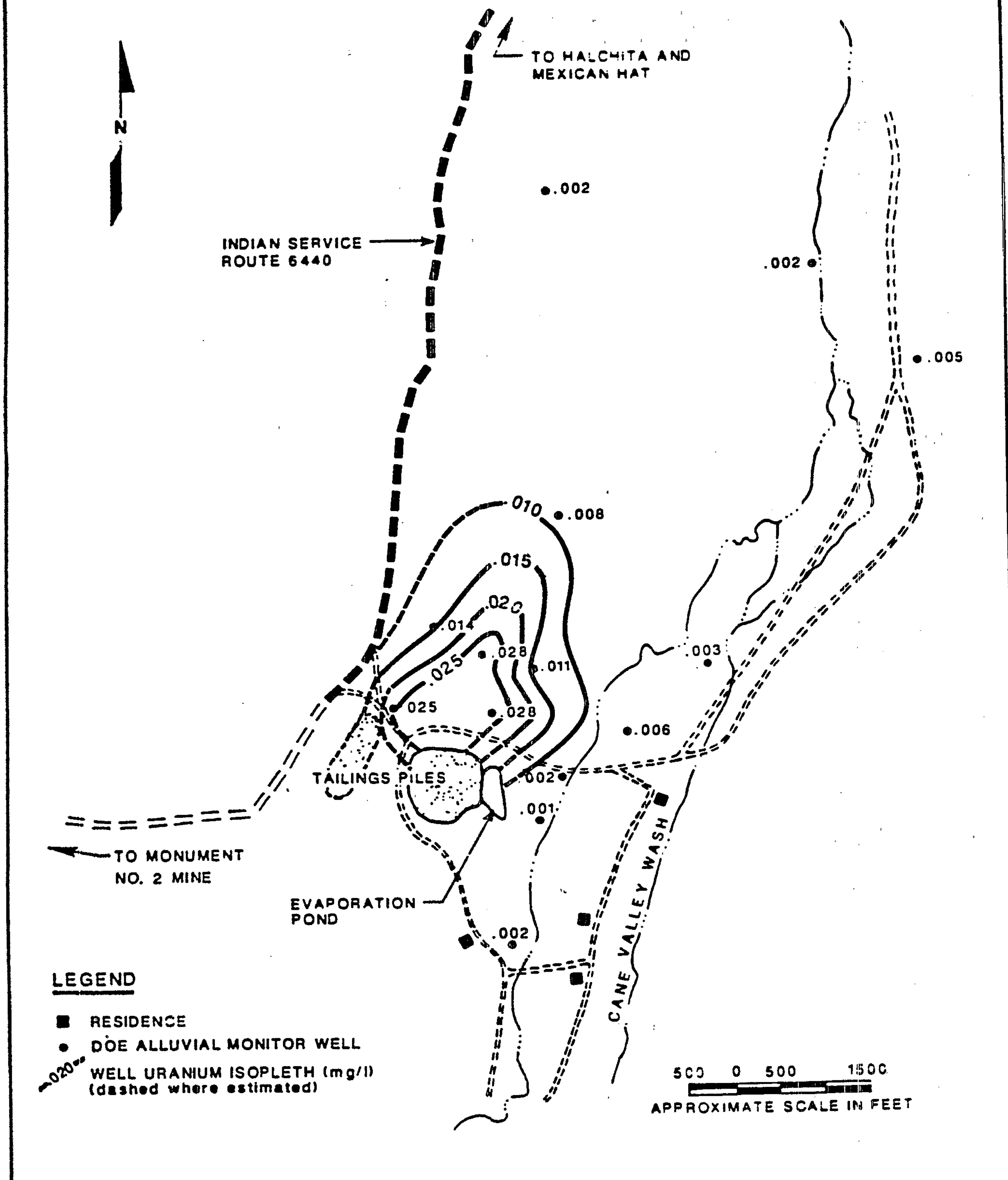


FIGURE 4-7 URANIUM PLUME, MONUMET VALLEY SITE

Table 4-37 Sampling for Hazardous Constituents in Uranium Mill Tailings Liquids[a]

Volatile Organic Compounds Not Found in Tailings Liquids

Bromoform
Carbon tetrachloride
Chlorobenzene
Chlorodibromomethane
Chloroform
Dichlorobromomethane
1,2 - dichloroethane
1,1,2,2 - tetrachloroethane
Tetrachloroethylene
1,1,1 - trichloroethane
1,1,2 - trichloroethane
Trichloroethylene

Semivolatile Organic Compounds Not Found in Tailings Liquids

2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
4,6 - Dinitro-O-Cresol
2,4-Dinotrophenol
2-Nitrophenol
4-Nitrophenol
P-Chloro-M-Cresol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol
Acenaphthene
Acenaphtylene
Anthracene
Acenaphtylene
Anthracene
Benzidine
Benzo(a)anthracene
Benzo(a)pyrene
3,4-Benzofluoranthene
Benzo(ghi)Perylene
Benzo(k)fluoranthene
Bis(2-Chloroethoxy) Methane
Bis(2-Chloroisopropyl Ether
Bis(2-Chloroisopropyl) Ether
Bis(2-Ethylhexyl) Phthalate
4-Bromophenyl Phenyl
Butyl Benzyl Phthalate
2-Chloronaphthalene
4-Chlorophenyl Phenyl Ether
Chrysene
Dibenzo(a,h)Anthracene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclo-pentadiene
Hexachloroethane
Indeno (1,2,3-cd)pyrene
Isophorene
Naphthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodi-N-Propylamine
N-Nitrosodiphenylamine
Phenantrhene
Pyrene
1,2,4-Trichlorobenzene
Aldrin
Alpha-BHC
Beta-BHC
Gamma-BHC
Delta-BHC
Chlordane
4,4-DDT
4,4-DDE
4,4-DDD
Dieldrin
Alpha-Endosulfan
Beta-Endosulfan
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
PCB-1242

Table 4-37 (continued)

1,4-Dichlorobenzene	PCB-1254
3,3'-Dichlorobenzidine	PCB-1221
Diethyl Phthalate	PCB-1232
Dimethyl Phthalate	PCB 1248
Di-N-Butyl Phthalate	PCB-1260
2,4-Dinitrotoluene	PCB-1016
2,6-Dinitrotoluene	Toxaphene
Di-N-Octyl Phthalate	
1,2-Diphenylydrazine (as Azobenzene)	

Hazardous Constituents Found in Tailings Liquids

Arsenic	Cyanide	Nickel
Barium	Fluorine	Radium 226 and 228
Beryllium	Lead	Selenium
Cadmium	Mercury	Thorium
Chromium	Molybdenum	Uranium

(a) from (SM87)

organonitrogen compounds, amines, as used in the Amex process. Flagg also reports that there was "very extensive research" in the development of several organic extractants for recovering uranium from sulfuric acid leach liquors. Thus, it appears reasonable to assume that several organic compounds were used at uranium mills, probably in the 1940's and 1950's.

Total organic carbon and total organic halogen concentrations were reported by DOE in ground water near several of the inactive sites, including some EPA priority pollutants (for example, see DOE-86a). While it appears this contamination is not from the tailings (the residual radioactive material), additional monitoring of ground water near the tailings sites may be needed to establish that the contamination is not a result of the tailings.

4.18 GROUND WATER CLASSIFICATION

Introduction

In August 1984, the U.S. Environmental Protection Agency (EPA) issued a Ground-Water Protection Strategy, setting out the Agency's plans for enhancing ground-water protection efforts by EPA and the States. A central feature of the Strategy is a policy framework for EPA's programs which accords differing levels of protection to ground water based on the resource's use, value to society, and vulnerability to contamination. A three-tiered ground-water classification system was established in the Strategy as a key operational tool to help implement this policy.

The Classification system recognizes that "special" ground water exists due to its high vulnerability to contamination and high value for drinking water purposes or its importance to a unique ecological habitat (Class I). The vast majority of the nation's ground water falls within Class II which encompasses all non-Class I current or potential sources of drinking water. Class III ground water is not a potential source of drinking water due to levels of contamination either from naturally occurring conditions or the effects of broadscale human activity, that cannot be feasibly cleaned up.

These Final Guidelines for classifying ground water augment the Ground-Water Protection Strategy by:

- o Further defining the key terms and concepts of the classification system, and

- Describing procedures and information needs to assist in classifying ground water.

The procedures in the Final Guidelines are generally intended for "site-specific" ground-water classification based on a review of the segment of ground water in relatively close proximity to a particular source. While the specific procedures are not designed specifically for broader aquifer classification, many of the concepts and procedures developed for site-by-site classification will also be useful in such classification efforts.

The manner and extent to which the Guidelines will be incorporated in EPA regulatory, permitting, and planning decisions are addressed in a supplemental Implementation Policy Statement being issued concurrently with the Guidelines.

The key criteria for each class, and procedural approaches for determining whether the criteria are met are outlined as follows:

Classification Review Area

The first step in making a classification decision is defining the area around the source that should be evaluated. Once this Classification Review Area (CRA) has been determined, information regarding public and private wells, demographics, hydrogeology, and surface water and wetlands is collected and a classification decision is made based on the criteria for each class as described below.

The Guidelines specify an initial Classification Review Area as the area within a two-mile radius of the boundary of the facility or activity under review. Under certain hydrogeologic conditions, an expanded or reduced Classification Review Area is allowed.

It should be emphasized that the Classification Review Area defines a "study area" necessary to evaluate the appropriate ground-water class, in connection with a specific site analysis, and not to imply that action needs to be taken relative to other facilities within the area.

Class I - Special Ground Water

Class I ground waters are defined as resources of particularly high value. They are highly vulnerable and either an irreplaceable source of drinking water for a substantial population or ecologically vital.

- Highly vulnerable ground water is characterized by a relatively high potential for contaminants to enter and/or be transported within the ground-water flow system. The Guidelines provide both quantitative and qualitative decision aids for determining vulnerability based on hydrogeologic factors.

- An irreplaceable source of drinking water for a substantial population is ground water whose replacement by water of comparable quality and quantity from alternative sources in the area would be economically infeasible or precluded by institutional barriers. The determination of irreplaceability is based on a three-step process that includes identifying the presence of a substantial population, applying screening tests designed to produce a preliminary determination, and reviewing relevant qualitative criteria in order to produce a final determination.

- Ecologically vital ground water supplies a sensitive ecological system located in a ground-water discharge area that supports a unique habitat. Unique habitats include habitats for endangered species listed or proposed for listing under the Endangered Species Act as well as certain Federally managed and protected lands.

Class II - Current and Potential Sources of Drinking Water and Ground Water Having Other Beneficial Uses

Class II ground waters include all non-Class I ground water that is currently used or is potentially available for drinking water or other beneficial use.

Subclass IIA is a current source of drinking water. Ground water is classified as IIA if within the Classification Review Area there is either (1) one or more operating drinking water wells or springs, or (2) a water supply reservoir watershed or portion that is designated for water quality protection by either a State or locality.

Subclass IIB is a potential source of drinking water. This ground water (1) can be obtained in sufficient quantity to meet the minimum needs of an average family; (2) has total dissolved solids (TDS) of less than 10,000 milligrams per liter (mg/l); and (3) is of a quality that can be used without treatment or that can be treated using methods reasonably employed by public water systems.

Class III - Ground Water Not a Potential Source of Drinking Water and/or Limited Beneficial Use

Class III drinking waters have either (1) a TDS concentration equal to or greater than 10,000 mg/l; or (2) contamination by naturally occurring conditions or by the effects of broadscale human activity that cannot be cleaned up using treatment methods reasonably employed in public water systems. A two-step test, based on technical and economic feasibility, is presented in the Guidelines. Class III also encompasses those rare conditions where yields are insufficient to meet the minimum needs of an average household. Subdivisions within Class III include:

Subclass IIIA ground water has an intermediate degree of interconnection with adjacent ground water units and/or are interconnected with surface waters.

Subclass IIIB ground water has a low degree of interconnection with adjacent ground water units.

4.19 REFERENCES

DOE84 U.S. Department of Energy, "Draft Environmental Assessment of Remedial Action at the Gunnison Uranium Mill Tailings Site," Dec 1984.

DOE86 U.S. Department of Energy, "Remedial Action Plan and Site Conceptual Design for Stabilization of the Inactive Uranium Mill Tailings Site at Monument Valley, Arizona," Feb 1986.

DOE86a U.S. Department of Energy, "Draft Environmental Impact Statement--Remedial Actions at the Former Climax Uranium Company Uranium Mill Site, Grand Junction, Mesa County, Colorado," DOE/EIS-0126-D, March 1986.

EPA84 Environmental Protection Agency, "Ground Water Protection Strategy," Washington, Aug. 1984.

EPA86a Environmental Protection Agency, "Guidelines for Ground Water Classification under the EPA Ground Water Protection Strategy," Final draft, Washington, Dec. 1986.

EPA86b Environmental Protection Agency, "Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites," EPA Contract No. 68-01-7090, Oct. 1986.

F161 Flagg, J.F., "Chemical Processing of Reactor Fuels," Academic Press, 1961.

Le87 Leske, D., Department of Energy, Albuquerque Operations Office, private communication, June 1987.

NUREG80 U.S. Nuclear Regulatory Commission, Final Generic Environmental Impact Statement on Uranium Milling, NUREG-0706, Sept 1980.

Sm87 Smith, R.D., U.S. Nuclear Regulatory Commission, "Sampling of Uranium Mill Tailings Impoundments for Hazardous Constituents," Memorandum to Robert E. Browning, Director, Division of Waste Management, NMSS, Feb 9, 1987.

CHAPTER 5

GROUNDWATER RESTORATION

5.1 TREATMENT TECHNOLOGY

Introduction

The purpose of this chapter is to identify groundwater restoration techniques that might be applicable to the removal and treatment of contamination at inactive uranium mill tailings sites and to evaluate the cost ranges of applying these techniques. The locations of the sites are shown in Figure 5.1. The groundwater treatment technologies discussed in this summary are presently available and applicable to hazardous wastes.

Processes and Techniques

Remedial actions that protect groundwater resources and associated surface water resources include aquifer restoration, elimination or limitation of the source of contamination, and containment of the contaminated groundwater. EPA has mandated long term, zero or minimal maintenance remedial actions for the UMTRA Project sites (40 CFR 192). Therefore, aquifer restoration and limitation of the source of contamination should be the primary considerations. Containment of groundwater should be considered only in support of aquifer restoration.

An appropriate water resource protection program at an UMTRA Project site might include some or all of the following:

- Physical removal of contaminated groundwater

- Temporary containment of contaminated groundwater, intruding uncontaminated groundwater or intruding surface water

- Treatment of contaminated water to meet appropriate water quality standards or goals

- Isolation of the contaminant source from the hydrologic regime

Isolation or at least partial isolation of the source of contamination is implemented by the use of a multi-layered cover above the source of contamination and possibly a layer of selected and reworked natural materials underlying the source of contamination. This approach is used to limit future contamination to non-pollutant levels and is not related directly to aquifer restoration. Therefore, this chapter will not discuss repository designs but will focus on the processes, technologies and costs of contaminated ground water restoration.

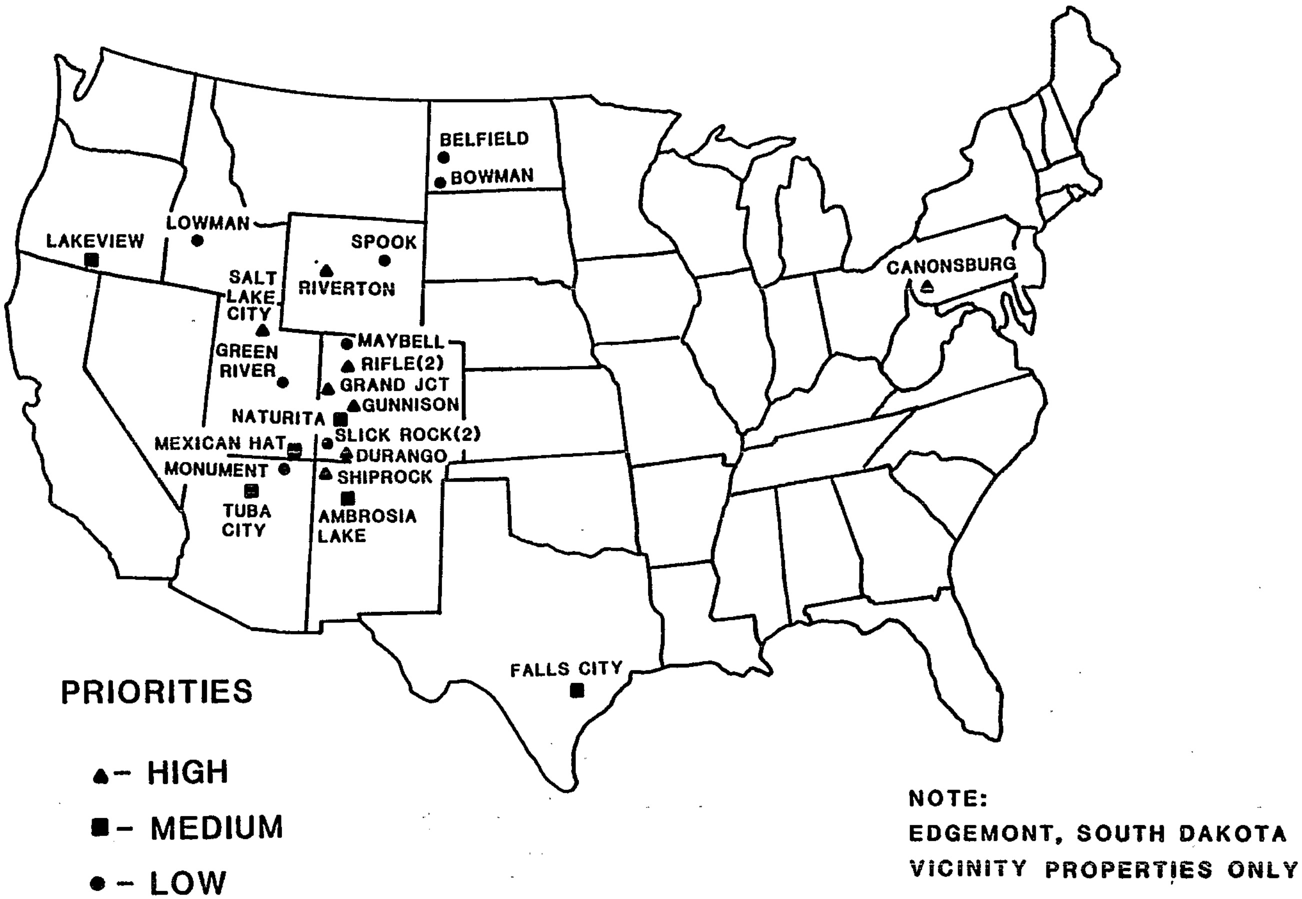


FIGURE 5.1 LOCATION - UMTRA PROJECT SITES

Physical Removal

Two methods can be used to remove contaminated groundwater: trenches and wells. The methodologies and technical considerations are discussed in this section.

Subsurface Drains/Trenches

Subsurface drains consist of underground gravel-filled trenches lined with tile or perforated pipe which intercept leachate or infiltrating water and transport it away from the wastes to a suitable point for treatment and/or disposal. Subsurface drains may be used in low permeability strata, such as clay or silty clay with permeability insufficient to maintain adequate flow to wells. The subsurface drain can provide a sufficient surface to create greater discharge rates than a well or series of wells could provide. Subsurface drains can also be used in more permeable sand and gravel. For sand and gravel, an open trench can be used or the permeability of the material in the trench must be significantly greater than the surrounding soil to make the trench effective.

Subsurface trenches are generally constructed by excavating a trench, laying perforated pipe or tile along the bottom, and backfilling with a coarse gravel to prevent soil fines from penetrating and clogging the soil pores. This procedure is confined to situations in which the contaminated groundwater is at a depth consistent with the capabilities of the trenching equipment, generally no more than 100 feet below the land surface. Advantages of this type of system include low operating costs, since flow is by gravity, considerable flexibility in design and spacing, and fairly good reliability when monitoring is provided.

Wells

Wells can be employed to extract or actively divert groundwater at or near a disposal site and are effective in any porous or fractured media which provide sufficient yields to wells. This technology may be employed to collect the groundwater for treatment, contain a contaminant plume, or to lower a water table. The number, spacing, depths, diameters, and completion intervals of wells in a well field can be optimized to remove contaminated groundwater cost-effectively. The goals of a restoration program should be developed and wells positioned to remove the specified contaminated groundwater while extracting only a limited volume of uncontaminated water. Pumping to lower a water table may be appropriate under several conditions, such as 1) lowering the water table in an unconfined aquifer so that contaminated groundwater dose not discharge to a hydraulically-connected receiving stream, 2) lowering the water table so that it is not in direct contact with the waste, or 3) lowering the water table to prevent contamination of an underlying aquifer.

Temporary Containment

Physical containment is accomplished through installation of a relatively impermeable barrier between contaminated and clean portions of the aquifer. Physical containment technologies include slurry walls, grout curtains, and sheet piling. Containment should be considered as support for physical removal of contaminated groundwater, rather than as a remedial action in itself. Containment methods are not proven long term solutions, therefore their application is limited to support of physical removal. For instance, at sites adjacent to rivers, such as the sites in Grand Junction and Durango, containment may be considered in controlling surface water inflow into the area of groundwater removal. Figure 5.2 shows the effect of a cutoff wall adjacent to a river. Also, containment may be appropriate where the advancing contaminant plume is approaching a presently used water resource.

Sheet Pile Cut-Off Walls

The construction of a sheet pile cut-off wall involves driving inter-locking piles into the ground with a pneumatic or steam pile driver. When first placed in the ground, the sheet pile cut-off allows easy water flow through the edge interlocks. However, with time, fine soil particles fill the seams and an effective barrier is formed. The performance life of a sheet pile cut-off wall can vary between seven and 40 years, depending upon the chemical characteristics of the surrounding soil. Sheet piling is feasible in situations where the water table is near the surface, a confining layer exists at a depth of less than 100 feet, and surficial materials are fine-grained to allow ease in driving the sheet metal. Sheet piling is not feasible for use in very rocky soils or for long-term containment.

Slurry Walls

Installation of a slurry wall involves excavating a trench through or under a slurry of bentonite clay and water, then backfilling the trench with the original soil (with or without bentonite mixed in). The trench is usually excavated down to a relatively impervious substratum to limit groundwater underflow. During the excavation process, the trench walls are supported by the slurry, preventing the walls from slumping or caving in, and eliminating the need for additional shoring materials. The process is designed to force the bentonite slurry through its own weight into the more permeable surrounding soils, forming a filter cake of low permeability which lines the walls and bottom of the trench. The application of slurry walls as relatively impermeable barriers is limited to areas where materials are trenchable and have sufficient permeability to form a filter cake. Trench depth is limited by the capabilities of the trenching equipment. This technology is practical only when groundwater contamination exists near the surface, generally

LOW-PERMEABILITY BARRIER REDUCES INDUCED FLOW FROM RIVER

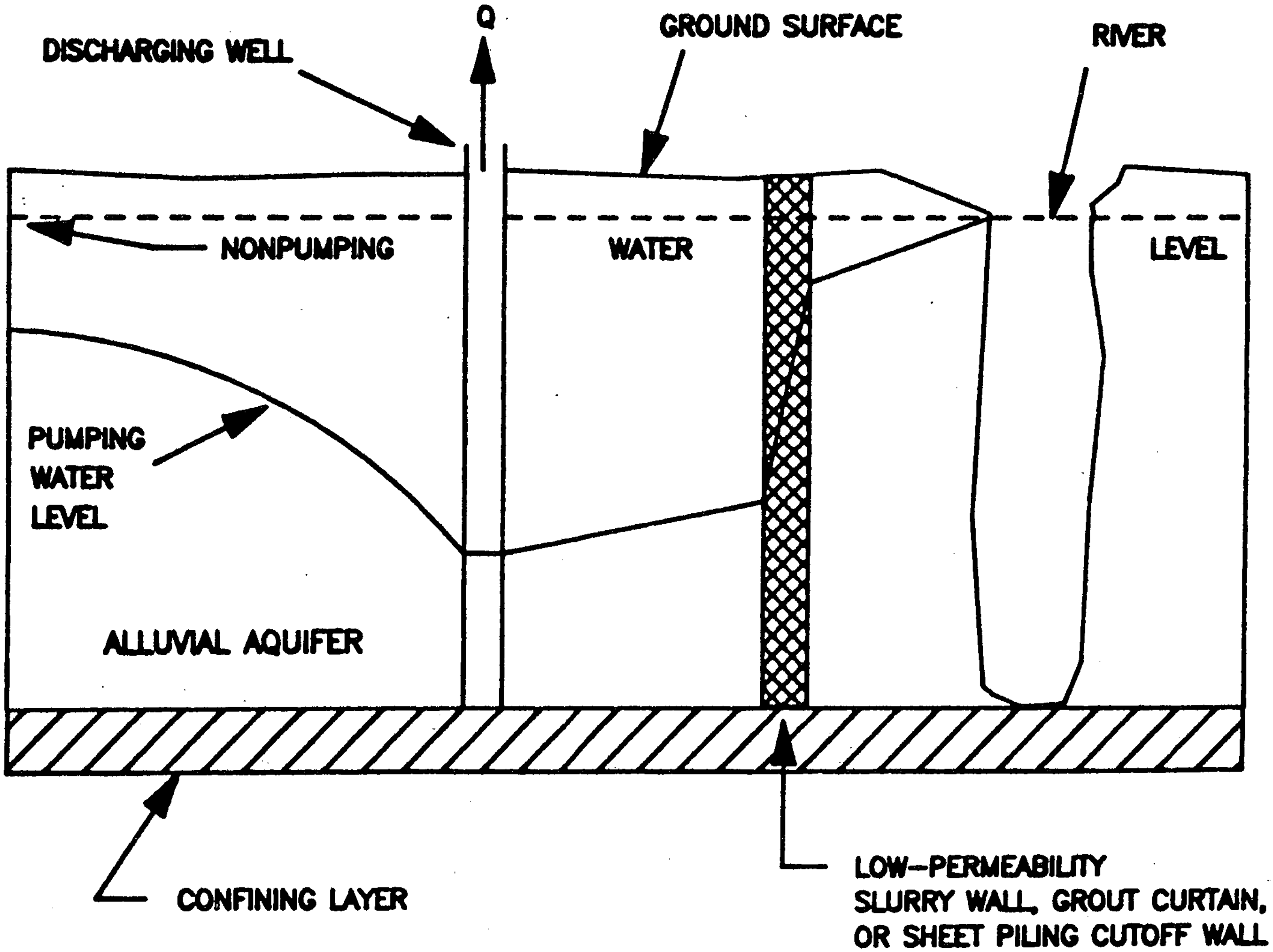


FIGURE 5.2

less than 100 feet in depth. Further, tests must be performed as part of the remedial action process to determine whether the slurry could be affected by chemical reactions with the contaminants, thus rendering it unsuitable for application. Slurry walls may be more appropriate for protecting surface water from contamination of discharging groundwater rather than containing the groundwater itself.

Grout Curtains

Grouting is the pressure injection of special fluids into a rock or soil body. The fluids set or gel in the voids in the rock and when carried out in the proper pattern and sequence, the process forms a wall or curtain that is an effective groundwater barrier. Due to the high cost of installing grout curtains, they are usually used only to seal voids in porous or fractured rock where other methods to control groundwater are not technically feasible.

Treatment Processes

After contaminated groundwater has been collected, the next step in aquifer restoration involves treatment of the water and the eventual reinjection into the groundwater or discharge to surface water. A variety of methods has been successfully employed in treating groundwater contaminated with typical contaminants (e.g. uranium, metals, sulfate and dissolved solids). Examples are chemical precipitation, evaporation, ion exchange, neutralization, and sorption.

Chemical Precipitation

The chemical precipitation process removes dissolved metals from aqueous wastes by chemically converting the metals into insoluble forms. The process is illustrated in Figure 5.3. Metals may be precipitated from solution as hydroxides, sulfides, carbonates or other salts. Hydroxide precipitation with lime is most common; however, sodium sulfide is sometimes used to achieve lower effluent metal concentration. This involves pH adjustment followed by the addition of sodium sulfide and a flocculant. Solids separation is achieved by standard flocculation--coagulation techniques. The resulting residuals are metal sludge and the treated effluent with an elevated pH and, in the case of sulfide precipitation, excess sulfide.

This technology is used to treat aqueous wastes containing metals, including zinc, arsenic, copper, manganese, mercury, cadmium, trivalent chromium, lead and nickel. A disadvantage of the method is that the pH which would precipitate one metal may allow other metals to remain soluble. Therefore, it may be difficult to attain an optimal pH for a given mix of metals. Also, chelating or complexing agents may prevent metals from

CHEMICAL PRECIPITATION AND ASSOCIATED PROCESS STEPS

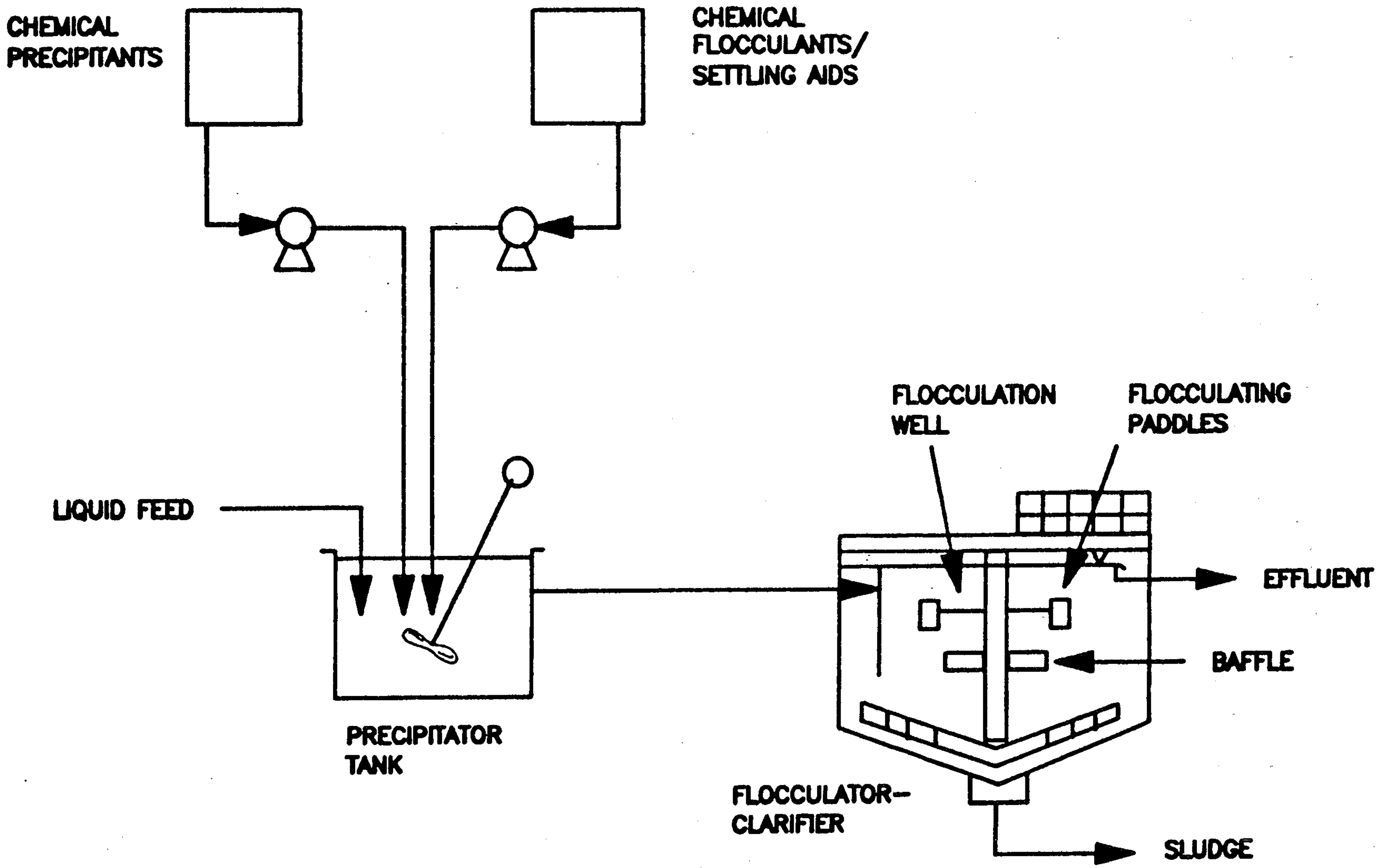


FIGURE 5.3

precipitating. Sulfide precipitation has been successfully used in numerous applications and often achieves lower concentrations levels than lime precipitation. However, the process does require close monitoring to function properly.

Most uranium milling operations employed acid leach processes to extract uranium. Therefore, chemical precipitation initiated by increasing the pH can be very effective in reducing the concentrations of radium, thorium, uranium, selenium, arsenic, cadmium, chromium, other trace metals and sulfate. Although some chemical precipitation resulted from neutralization in the subsoils at most sites due to the abundance of calcite in the soils, enhanced precipitation may be applied with a treatment plant to further lower the concentrations of metals that complex with mobile anions. Sulfide precipitation may be most effective in this enhanced treatment.

Evaporation

Evaporation is defined as the physical separation of a liquid from a dissolved or suspended solid by the application of energy to volatilize the liquid. Evaporation may be used to concentrate a hazardous or toxic material, thus reducing the volume of waste requiring subsequent treatment of disposal. Evaporation can be carried out in a large pond with sunlight providing the energy.

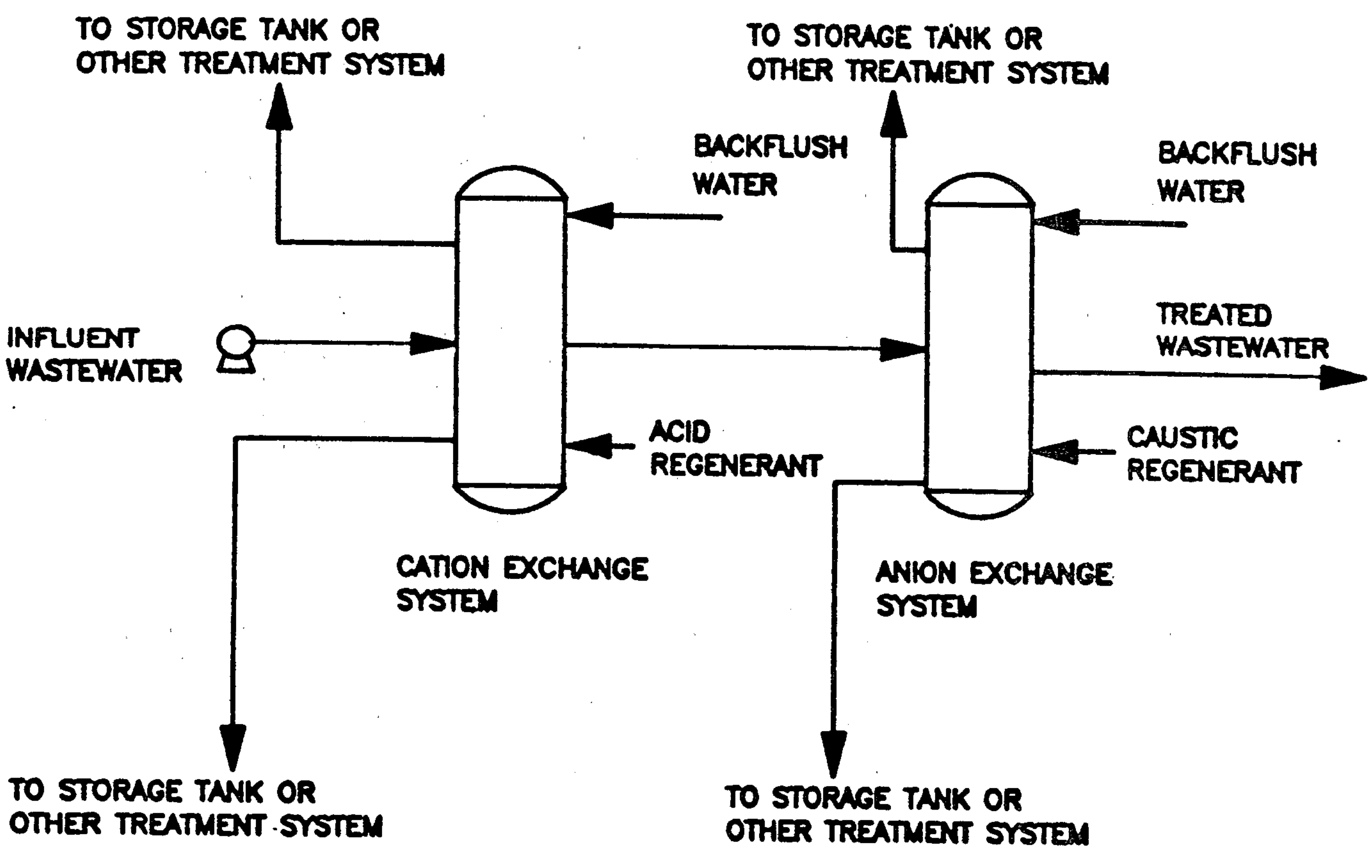
Most uranium milling sites are in semi-arid climates where potential evaporation greatly exceeds precipitation. Therefore, a pond to evaporate discharged groundwater from dissolved contamination is a potentially viable treatment technique. Following evaporation, the residual solids could be incorporated into the tailing repository for "permanent" disposal.

Ion Exchange

Ion exchange removes toxic metal ions from solution by exchanging one ion, electrostatically attached to a solid resin material, for a dissolved toxic ion. The process is illustrated in Figure 5.4. The resulting residuals include spent resins and spent regenerants such as acid, caustic or brine. This technology is used to treat metal wastes including cations (Ni^{2+}, Cd^{2+}, Hg^{2+}) and anions (chromates, selenates, arsebates). The effectiveness of the process may be limited by competition for exchange sites between contaminated metals. Other disadvantages are difficulties in obtaining and maintaining an optimal pH for efficient removal and the inefficiency of the process in treating groundwater with high concentrations of suspended solids. The oxidizing agent concentration should be greater than 50 milli-equivalent per liter (meq/l) for practical operation. Highly concentrated waste streams (>2500 mg/l contaminants) or high solid concentrations (>50 mg/l) should be avoided.

FIGURE 5.4

SCHEMATIC OF ION EXCHANGE



Neutralization

Neutralization renders acidic or caustic wastes non-corrosive by adjustment of the pH. The residuals include insoluble salts, metal hydroxide sludge, and neutral effluent containing dissolved salts. The final desired pH is usually between 6.0 and 9.0.

Neutralization is used to treat corrosive wastes, both acids and bases. A disadvantage of the process is the need to dispose of highly concentrated sludges and solids.

Significant neutralization occurs at Western uranium milling sites directly beneath and downgradient of the tailings source material due to calcite in the shallow soils. The neutralization causes precipitation of gypsum and the coprecipitation, occlusion and adsorption of radionuclides and trace metals.

Sorption

Contaminants are bound up in pozzolan-type matrices by physical sorption or chemisorption yielding a stabilized material which is easier to handle. The process is illustrated in Figure 5.5. Liquid immobilization depends on added ingredients. This process results in high concentrations of contaminants at the surface of the material and contaminants may leach. The treated material is permeable.

Sorption can be used for organics and inorganics. The advantages to this technology are that raw materials are readily available, the mixing technology is known, the waste form is relatively easy to handle, additives are inexpensive, minimum pretreatment is required, and bearing strength is adequate for landfill. Disadvantages are that large volumes of additives are needed, the results are sensitive to the placement and packing of the matrices, free water may be released under pressure and changes in temperature may affect the results.

Landfarming

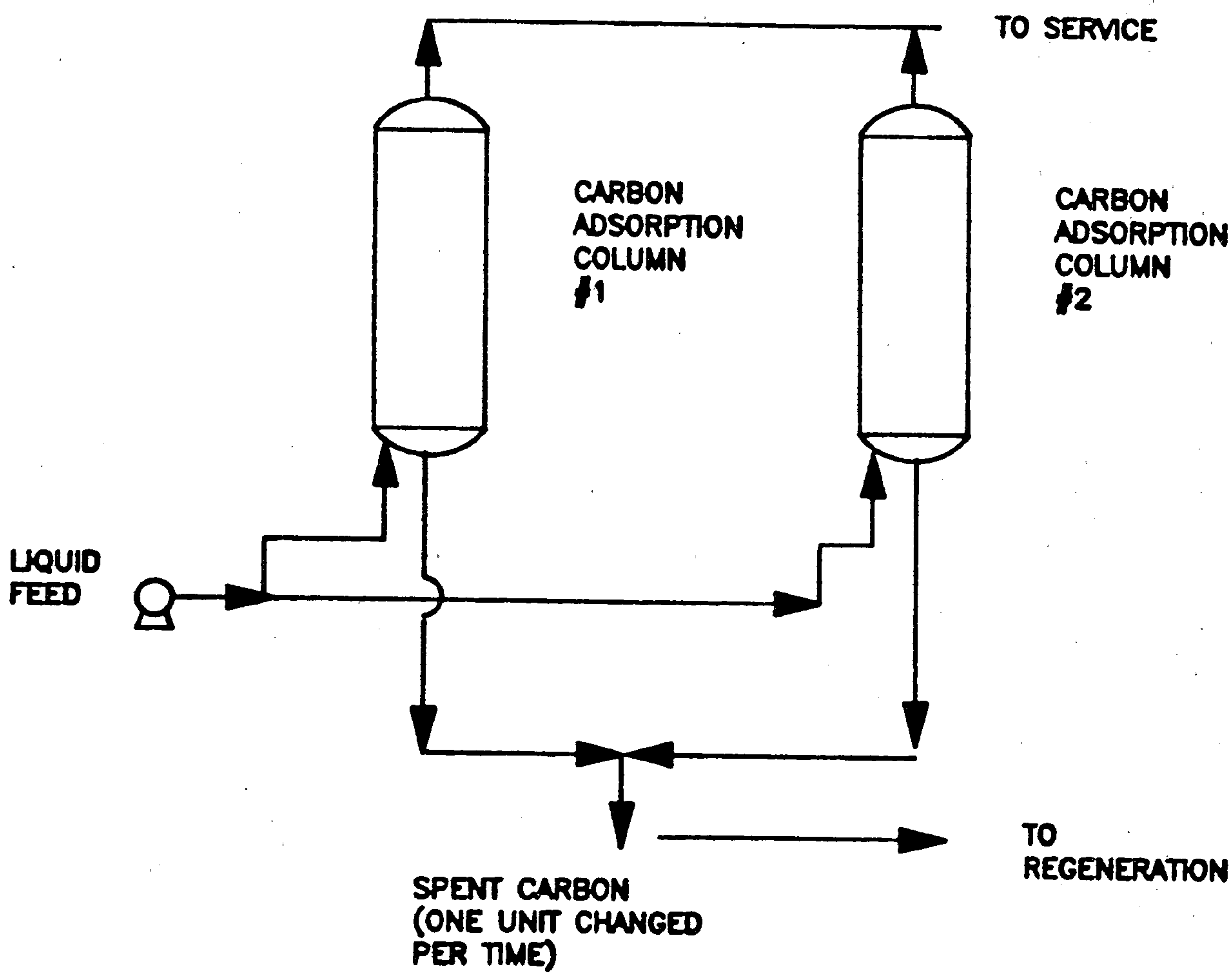
Landfarming is a technique where contaminated soil is incorporated into the top 6 to 8 inches of soil along with concentrated microbial populations. It is used to biodegrade, volatilize or leach organics. It is not applicable to the inorganic contamination at uranium milling sites (WESTON, 1983).

Reverse Osmosis

Reverse osmosis is a membrane process to remove dissolved ions from saline water using hydrostatic pressure to drive the feedwater through a semipermeable membrane. The major portion of the ions remain on the feed side of the membrane and is

FIGURE 5.5

SCHEMATIC OF CARBON ADSORPTION



discharged as waste. The osmotic pressure needed for successful treatment can be estimated as 1 psi/100 mg/l of TDS.

Modern reverse-osmosis membranes are constructed in a modular form, most common are spiral wound and hollow fine fiber. The modules are mounted in containment pressure vessels. Reverse osmosis is most successful in treating water with less than 10,000 mg/l TDS to produce water with less than 500 mg/l, i.e., potable quality (Montgomery, 1985). The cost for reverse osmosis ranges from $500 per million gallons treated for water containing approximately 10,000 mg/l TDS to $1500 per million gallons treated for water containing approximately 30,000 mg/l TDS (Thompson, 1987).

In Situ Treatment

There are three general categories of in situ treatment processes for the remediation of contaminated ground water: biological, chemical, and physical. Of these, only the chemical treatment technologies are generally capable of neutralizing or immoblizing the ground water contaminants normally found at the UMTRA sites. In situ chemical treatment involves the injection of chemicals into the contaminated aquifer under carefully controlled conditions to immobilize or neutralize the contaminants. Typical chemical treatments include neutralizing the pH to induce precipitation of contaminant cations and/or anions, change of chemical forms to encourage chelation, and formation of compounds which are less mobile or less degrading to water quality.

Implementation would require extensive characterizations of the local geology, hydrology and geochemistry, followed by site-specific pilot testing. The site geology, hydrology, and geochemistry must allow adequate contact between the treatment agents and the contaminated ground water, control migration of the treatment agents and the contaminants, and allow recovery of spent solutions and/or contaminants if necessary. If pilot tests indicated the method to be feasible, project costs would include installation of wells and pumps for injection, withdrawal and monitoriing, facilities for handling the chemicals for treatment, control sampling, etc. Costs for a well field and ground water pumping would be 500 to 1500 dollars per million gallons. Costs for treatment of the water and reinjection are estimated at 500 dollars per million gallons. Total costs should be much less than typical chemical treatment since it is estimated that only 20% to 50% of the contaminated ground water would be pumped, treated, and reinjected.

5.2 VOLUMES OF CONTAMINATED GROUND WATER

Introduction

From a technical standpoint, three factors govern the feasibility, effectiveness and costs of aquifer restoration.

These are 1) the volume of contaminated groundwater, 2) the ease with which it can be removed, and 3) its treatability. When a vast volume of groundwater is contaminated or when an aquifer is hydraulically connected to a surface water body, it may neither be technically nor economically feasible to pump, treat, and recharge the contaminated wastes. Similarly, in a situation for which the aquifer is thin, discontinuous, heterogeneous, or of a low permeability, aquifer restoration also may not be feasible. Finally, while it may be technically and economically feasible to collect contaminated groundwater, it is possible that the type and/or levels of contamination may not be treatable. These factors must all be considered in selecting the scope of aquifer restoration and the applicable technologies.

Site Descriptions

In this section, each of the sites is described, with emphasis on the estimated volume of contaminated groundwater, the appropriate method to extract the contaminated groundwater, and the value of the contaminated groundwater relative to its present or potential use. Volumes of contaminated groundwater are summarized in Table 5.1.

Ambrosia Lake

The estimated volume of contaminated groundwater at the Ambrosia Lake site is 650 million gallons. The tailings lie on unconsolidated materials. The shallow groundwater occurs 10 to 40 feet beneath the ground surface. The deeper tailings are saturated. The groundwater contained in the tailings, alluvium, fractured Mancos Shale, and Tres Hermanos Sandstone probably resulted for surface discharges of mine dewatering. Given that the depth of contamination is relatively shallow and yields to wells are minimal, contaminated groundwater could be extracted more efficiently with trenches than with wells. Following remedial action, given that mining and dewatering has ceased in the area, the contaminated groundwater will probably dissipate through discharge into the mine shaft in the Wastewater Canyon Member of the Morrison Formation and the presently saturated shallow zones will desaturate.

Canonsburg

The volume of contaminated groundwater at the Canonsburg site is approximately 100 million gallons. The remedial action at the Canonsburg site was completed in 1986. Groundwater at the expanded Canonsburg site is unconfined in the unconsolidated material (fill, soil, and alluvium) and is semi-confined in the underlying bedrock. Given that the contamination is relatively shallow, trenches would appear to be the preferred method for groundwater removal. Depth to groundwater is zero to eight feet. Recharge to the unconsolidated material is from direct infiltration of precipitation and from groundwater flow onto the expanded Canonsburg site from the south. Chartiers Creek is the discharge area on the western, northern, and eastern sides of the site for the unconfined groundwater. Groundwater in the shallow bedrock may pass beneath the site. Groundwater in the area has very limited use for gardening and other outdoor uses.

Durango

Subsurface investigations at the Durango site were limited by the steep, unstable slopes of tailings and smelter slag at the site. A rough estimate of the volume of contaminated groundwater at the site is 500 million gallons. The depth to groundwater ranges from approximately ten to 50 feet below land surface. The contamination is primarily in the alluvium and is naturally contained by a thick bed of Mancos Shale underlying the alluvium. Trenching would be preferred over pumping to extract contaminated groundwater due to the relatively shallow depth of contamination. The site is within 500 feet of the Animas River. A cut-off wall may be necessary during aquifer restoration to prevent the inflow of surface water from the Animas River.

Grand Junction

The volume to contaminated groundwater at the Grand Junction site is approximately 700 million gallons. Shallow unconfined groundwater occurs in the alluvium on the Colorado River and is separated from confined groundwater by approximately 200 feet of relatively impermeable Mancos Shale. Shallow groundwater is not used in the area. Most of all of the contaminated groundwater could probably be removed with trenches. A cutoff wall may be required during groundwater removal to limit the inflow of water from the Colorado River. Return irrigation flow passes under and possibly through the tailings pile. The water table over much of the site rises above the base of the tailings. During most of the year, shallow groundwater flows toward the Colorado River. Water quality analyses indicate no river contamination due to tailings seepage.

Gunnison

Approximately two billion gallons of groundwater are contaminated at the Gunnison site. Shallow groundwater is the major water supply in the Gunnison area. The Gunnison site rests on a massive alluvial deposit that is more than 100 feet thick. It rests at the confluence of two large regional groundwater aquifers comprised of the Gunnison River and Tomichi Creek water sheds. The depth of the groundwater varies by six to eight feet annually and is near or above the base of the tailings during the summer months. Contamination may be up to approximately 100 feet deep. Because the contamination is relatively deep, covers a broad area and the sediments are relatively permeable, pumping is the preferred method for groundwater extraction for aquifer restoration.

Lakeview

The estimated volume of contaminated groundwater at the Lakeview site is three billion gallons. Groundwater at depths greater than 100 feet is the major water supply in the Lakeview area. The depth of contamination is approximately 50 to 75 feet below land surface. Groundwater occurs under both confined and unconfined conditions with a water table that varies seasonally from zero to 15 feet below the ground. Because the contamination is relatively deep and the sediments are relatively permeable, pumping is the preferred method for ground water extraction for aquifer restoration.

Mexican Hat

The estimated volume of contaminated groundwater at the Mexican Hat site is 90 million gallons. The tailings rest on very dense, tight siltstone. The Mexican Hat site is about five miles away from the nearest exposure of permeable strata. Except for areas of local ponding, the fine-grained nature of the tailings and the high evaporation rates of the region allow only limited amounts of precipitation to infiltrate into the tailing. Capillary forces in the tailings may be sufficient to preclude percolation of tailings water to the underlying bedrock. The depth to the water table is not known but is assumed to be greater than 50 feet. Because the contamination is relatively deep, pumping would be the preferred method to remove groundwater for aquifer restoration. The ambient water quality is poor (only industrial use is possible without extensive treatment).

Monument Valley

Approximately three billion gallons of contaminated groundwater lie beneath and downgradient of the Monument Valley site. Shallow groundwater is used by several local dwellers. The tailing piles are all sand (no slime), all precipitation is absorbed and there is little evidence of any surface runoff from the piles. The rock unit that forms the shallowest confined aquifer near the mill site is the Shinarump Conglomerate Member of the Chinle Formation. This rock unit is exposed immediately west of the tailings piles, and most of the abandoned mill building foundations and settling pond sites are located on outcrops. The Shinarump Member consists of poorly sorted sand, grit, and pebble-size conglomerate. Unconfined groundwater is very near the surface along the main axis of Cane Valley Wash. The unconfined water moves through the alluvium of Cane Valley Wash and is recovered near the site from shallow wells. These shallow wells and springs are recharged from local runoff. Contamination extends to depths of up to 100 feet. The depth and large area of contaminated groundwater and relatively permeable soil and rock indicate that pumping is the preferred method of groundwater extraction for aquifer restoration.

Riverton

The volume of contaminated groundwater at the Riverton site is approximately one billion gallons. Groundwater levels are generally less than six feet below the tailings foundation interface and periodically groundwater rises toward and into the lower portions of the tailings pile. A confined aquifer system is present in the underlying bedrock. The unconfined system and the first confined system are separated by about 25 feet of shale, siltstone, and mudstone bedrock. The unconfined groundwater quality is briny and is not a source of potable water. The unconfined aquifer has been contaminated. Contaminated groundwater could be removed using trenches. The confined groundwater is a major source of potable water in the Riverton area. It has not been contaminated as indicated by most of the site groundwater quality data.

Salt Lake City

The volume of contaminated groundwater at the Salt Lake City site is estimated to be 1.6 billion gallons. The Salt Lake City site is underlain by an unconfined aquifer which overlies a confined aquifer. Both aquifers consist of interbedded clays, silts, and sands. The shallow groundwater has been contaminated. Trenching could be used to extract the contaminated groundwater. Hydrologic data indicate the unconfined aquifer is about 60 feet thick near the site. The unconfined aquifer is recharged by upward leakage from the confined aquifer and infiltration of precipitation and snowmelt. The unconfined aquifer is generally encountered initially at a depth of about 75 feet. The major source of recharge to this aquifer is infiltration of precipitation and runoff from the foothills of the Wasatch Mountains. The flow direction in both aquifers is to the west and northwest. The confined aquifer has not been contaminated significantly. The unconfined aquifer is characterized by very high total dissolved solids, iron, sulfate, and sodium, and is not usable as a potable water supply anywhere in the area. The confined aquifer is potable and will continue to be used as a water supply.

Shiprock

The volume of contaminated groundwater beneath the site is estimated to be 850 million gallons and the contamination of the floodplain deposits along the San Juan River is estimated to be 400 million gallons. Groundwater characterized by TDS in excess of 20,000 ppm exists in the alluvial deposits and weathered Mancos Shale between 13 and 50 feet below the surface underlying the tailings repository. The relatively flat, shallow groundwater gradient is towards the escarpment above the flood plain of the San Juan River where only slight seepage has been found. The shallow groundwater is contaminated beneath the tailings; however, it is separated by hundreds of feet of relatively impermeable Mancos Shale from the regional aquifer. The contaminated groundwater in the floodplain deposits below the escarpment along the San Juan River could be extracted with trenches. Floodplain groundwater is used for all purposes by local dwellers across the San Juan River from the site. Removal of the contamination beneath the site may require pumping.

Tuba City

Approximately 1.2 billion gallons of groundwater in the Navajo Sandstone has been contaminated at the Tuba City site. The principal aquifer and water supply in the Tuba City-Moenkopi area is a multiple aquifer system consisting of Navajo Sandstone and some sandstone beds in the underlying Kayenta Formation. This aquifer is recharged by winter and spring precipitation in the Kaibito Plateau highlands some distance north of Tuba City. The depth to the water table is approximately 50 feet. Contamination has extended to depths of up to 150 feet, therefore wells would be needed to extract the contaminated groundwater.

5.3 AQUIFER RESTORATION COST RANGES

Unit costs ranges for groundwater removal methods, cut-off walls and treatment methods are presented in Table 5.2. The likely unit costs are also presented.

Table 5.1 Volumes of Contaminated Ground Water at Selected Inactive UMT Sites

SITE	AMOUNT OF CONTAMINATED WATER (MGAL) MIN	MAX	AMOUNT OF CONTAMINATED WATER (MGAL) LIKELY
Ambrosia Lake	500	800	650
Canonsburg	75	125	100
Durango	300	700	500
Grand Junction	500	900	700
Gunnison	1500	2500	2000
Lakeview	2500	3500	3000
Mexican Hat	60	120	90
Monument Valley	2500	3500	3000
Riverton	800	1200	1000
Salt Lake City	1200	2000	1600
Shiprock	1000	1500	1250
Tuba City	1000	1500	1250

TABLE 5.2. UNIT COSTS FOR GROUND WATER RESTORATION METHODS

TREATMENT METHODS	TOTAL COST (DOLLARS)
1) Slurry Wall	54.00 - 110.00/Cubic Yard
2) Grout Curtains	162.00 - 330.00/Cubic Yard
3) Sheet Pilings	15.00/Sq Ft of Wall
4) Subsurface Drains	500.00 - 1000.00/MGAL Treated
5) Evaporation Ponds	1.50 - 5.00/Sq Foot of Pond
6) Groundwater Pumping	500.00 - 1500.00/MGAL Treated
7) Chemical Precipitation	500.00 - 1200.00/MGAL Treated
8) Ion Exchange	500.00 - 1000.00/MGAL Treated
9) Neutralization	500.00 - 1200.00/MGAL Treated
10) Sorption	1000.00 - 1400.00/MGAL Treated
11) Reverse Osmosis	500.00 - 1500.00/MGAL Treated
12) In Situ Treatmemt	1000.00 - 2000.00/MGAL Treated

Likely Unit Costs (DOLLARS)

ITEM	MIN.	MAX.	LIKELY
Containment (/FT2)	10	20	15
Pumping (/MGAL)	500	1500	1000
Trenching (/MGAL)	500	1000	750
Treatment (/MGAL)	500	1400	950

5.4 REFERENCES

Clean-up of Chemical Contaminated Site, Chemical Engineering, February 21, 1983, V90, n4, p.73(9)

Environmental Assessment of Remedial Action at the Riverton Uranium Mill Tailings Site, U.S. Department of Energy, DOE/EA-0254, July 1985

Handbook, "Remedial Action at Waste Disposal Sites." USEPA, EPA 625/6-82-006

Handbook, "Leachate Plume Management." USEPA, EPA 5-40/2-85/004

Jacobs Engineering Group, "Aquifer Protection and Restoration Alternatives and Cost Considerations"

Lauch, R.P., and Cuter, G.A., "Ion Exchange for the Removal of Nitrate From Well Water." Journal AWWA, 78:5:83, May 1986

Montgomery, James M. "Water Treatment Principles and Design", John Wiley & Sons, Inc., 1985.

Sorg, T.J., "Treatment Technology to Meet the Interim Primary Drinking Water Regulations for Inorganics," Journal AWWA, 70:2:105, February 1978

Summary Report, "Remedial Response at Hazardous Waste Sites," USEPA, EPA 540/2-84-002 A & B

Thompson, Bruce, Personal Communication, University of New Mexico, May 1987.

Wagner, K., and Z. Kosin. 1985. In situ treatment. In: The Sixth National Conference on Management of Uncontrolled Hazardous Waste Sites, November 4-6, 1985, Washington, D.C. Hazardous Materials Control Research Institute, Silver Spring, MD.

Roy F. Weston, "Installation Restoration General Environmental Technology Development," Report No. DRXTH-TE-CR-83249, December 1983.

Roy F. Weston, "Solvent and Heavy Metals Removal from Groundwater," Report No. DRXTH-TE-CR-82176, January 1983.

CHAPTER 6

COSTS OF GROUND WATER RESTORATION AND MONITORING

The costs of ground water restoration can vary greatly among sites, as discussed in the previous chapter. The purpose of this chapter is to consider the major capital and operation cost components to arrive at a single estimate of the total ground water cleanup cost for all 24 sites. The major cost components are the amount of contaminated ground water, the amount of contaminated ground water that must be removed from below the surface, and any treatments that must be given the contaminated ground water. Costs are also estimated for monitoring of ground water and at water treatment plants.

6.1 AMOUNT OF CONTAMINATED GROUND WATER

The volume of ground water that is contaminated is estimated from well data and the geological structure in the locale of the tailings pile. Well data indicate the area of the contaminated plume and also provide some characteristics of the local geology. The presence of confining layers (aquitards) limits the vertical spread of the contamination, unless there are interconnections with other aquifers. The vertical distance between confining layers when combined with the area of the contaminated plume yields the volume of the contaminated aquifer. The volume of water is determined using the porosity of the rocks in the aquifer.

The many variables in this determination lead to uncertainty. Estimated uncertainties in the amount of contaminated water shown in Table 5.1 range from ± 17% to ± 40% from the midpoint values. Since there is no evidence that these volumes are skewed (i.e., purposefully over- or under-estimated), the midpoint values are used to estimate total costs. The volumes of contaminated ground water are listed in Table 6.1.

6.2 AMOUNT OF GROUND WATER TO BE REMOVED

The total cost of ground-water restoration is directly proportional to the total amount of ground water that must be processed. Typically, this total quantity of water is expressed as the number of volumes of contaminated ground water that must be removed to restore ground-water quality. For example, the amount of contaminated ground water at Ambrosia Lake is 650 million gallons (Mgal). If the total amount of ground water to be processed is five volumes, the total amount is 3250 Mgal.

Table 6.1 Aquifer Restoration Cost Estimates[a]

Site	Amount of Contaminated Water (10^6 gal)	Pumping Cost (10^6 \$)		Trenching Cost (10^6 \$)	Treatment[b] Cost (10^6 \$)		Containment Cost (10^6 \$)
		Install	Operate		Install	Operate	
Ambrosia Lake	650			2.44	0.62	2.47	
Canonsburg	100			0.38	0.10	0.38	
Durango	500			1.88	0.48	1.90	1.4[c]
Falls City	4000						
Grand Junction	700			2.63	0.67	2.66	0.7[d]
Gunnison	2000	2.50	7.50		1.90	7.60	
Lakeview	3000	3.75	11.25		2.85	11.40	
Maybell	180						
Monument Valley	3000	3.75	11.25		2.85	11.40	
Rifle - New	700			2.63	0.67	2.66	
Riverton	1000			3.75	0.95	3.80	
Salt Lake City	1600			6.00	1.52	6.08	
Shiprock	1250			4.69	1.19	4.75	
Slick Rock - NC	30			0.11	0.03	0.11	
Slick Rock - UC	23			0.09	0.02	0.09	
Spook	180			0.68	0.25	0.86	
Tuba City	1250	1.56	4.69		1.19	4.75	

(a) Cost estimates are for processing five volumes of contaminated water over 15 years. Unit costs are \$15/sq. ft. for containment, \$1,000/Mgal for pumping, \$750/Mgal for trenching and \$950/Mgal for treatment.
(b) Assumes all water is treated. These costs may be much less for some sites if effluent limitations guidelines are met for direct discharges to rivers, or if land disposal is feasible.
(c) Containment area is 62,500 sq. ft.
(d) Containment area is 35,000 sq. ft.

Estimating the number of volumes to be extracted on a generic basis is uncertain. Restoration is greatly dependent on the chemical characteristics of the aquifer rock, which can be expected to vary widely among sites. In a review of in situ uranium mining at eight sites (NUREG86), considerable variability was found in the number of volumes needed to significantly reduce hazardous constituents in the ground water. Restoration of the ground water at these sites was complicated due to the processing solvent (lixiviant) that was used to dissolve the uranium. An important finding was that, for those cases where significant restoration was achieved, almost all the cleanup occurred in the first few volumes removed.

Based on the discussion in Chapter 5, a value of five volumes of contaminated ground water is selected as the best quantity for estimating costs of restoration. Selective chemistry may be used at some sites to enhance restoration, as well as injection of treated (clean) water to flush (sweep) contaminants from the aquifer. Such actions are site specific and not amenable to assessment in this generic analysis.

6.3 TREATMENT OF CONTAMINATED GROUND WATER

Treatment costs vary from $500.00 to $1,400.00 per Mgal treated (See Table 5.2). Since seven treatment methods are available for application at any particular site, it appears likely that the midpoint of the cost range can be achieved when averaged over all sites. Therefore, the midpoint value of $950.00 per Mgal of water treated is selected for use in this assessment.

6.4 ESTIMATED COST OF RESTORATION TREATMENT

The estimated cost of ground water restoration is shown in Table 6.1 for the sites for which sufficient data are available. The procedure includes:

- o A choice is made whether trenches or wells would be the preferred method of groundwater removal. Then the unit cost range is applied for the chosen method.

- o Cut-off wall costs are estimated for the two sites where river inflow may need to be controlled.

- o Site-specific treatment methods are not specified because the unit cost ranges do not vary significantly between the various treatment methods. A treatment cost of $950 is used for all sites.

- o It is assumed that five times the volume of contaminated ground water needs to be extracted to restore adequate ground water quality.

The cost estimates include the major items required in an aquifer restoration program and assume that all ground water must be restored at all sites by treatment. Some of the items not included in the cost estimates are:

- monitoring equipment
- data collection
- discharge or reinjection facilities and operations
- removal amd remediation of facilities
- final revegetation and well abandonment.

Pumping costs and treatment plant operating costs are costs that will occur over a period of 5 to 53 years (DOE 88c). Therefore, estimating the operating costs separately will allow the present value of these costs to be estimated. The values for the operating costs and present worths at 5% and 10% are presented in Table 6.2.

6.5 ESTIMATED COST OF MONITORING

Monitoring costs will be incurred both at the treatment plants and for ground-water sampling at wells. The cost estimates for monitoring are developed separately in this section.

6.5.1 Estimated Monitoring Costs at Treatment Plants

Monitoring at the treatment plant consists of collecting composite samples of the inflow water and the outflow water on a routine schedule. These samples are analyzed for indicator nuclides or chemicals that denote that the process is working efficiently and that discharge quantities are within specifications. The frequency of these analyses varies due to several factors, including the rate of change in inflow concentrations and process upsets in the plant.

The estimated cost of monitoring at the treatment plants is based on information supplied by DOE (DOE 88b). DOE estimated that ground water would require treatment at 17 sites, that the period of operation of treatment plants would vary from less than 5 years to 53 years, that the monitoring frequency schedule could be reduced over the operating lifetime as:

Table 6.2 Ground-Water Restoration Cost Estimates at 17 Sites Chosen by DOE for Active Restoration

Site	Operating Time (years)	Cost ($M) (a) Install	(a) Operate	at 5% Operate	at 5% Total	at 10% Operate	at 10% Total
Ambrosia	10	3.06	2.47	1.91	4.97	1.52	4.58
Canonsburg	5	.48	.38	.33	.81	.29	.77
Durango	5	2.36	1.90	1.65	4.01	1.44	3.80
Falls City	53	15.00(b)	19.00	6.63	21.63	3.56	18.56
Grand Junc	5	3.30	2.66	2.30	5.60	2.02	5.32
Gunnison	5	4.40	15.10	13.08	17.48	11.45	15.85
Lakeview	5	6.60	22.65	19.61	26.21	17.17	23.77
Maybell	5	.93(b)	.86	.74	1.67	.65	1.58
Monument V	23	6.60	22.65	13.28	19.88	8.75	15.35
Naturita	5	.36(b)	.45	.39	.75	.34	.70
Rifle-New	5	3.30	2.66	2.30	5.60	2.02	5.32
Riverton	13	4.70	3.80	2.75	7.45	2.08	6.78
Shiprock	5	5.88	4.75	4.11	9.99	3.60	9.48
Slick-NC	5	.11(b)	.14	.12	.23	.11	.22
Slick-UC	5	.09(b)	.11	.10	.19	.08	.17
Spook	32	.93(b)	.86	.42	1.35	.26	1.19
Tuba City	22	2.75	9.44	5.65	8.40	3.76	6.51
		60.85	109.88				
		170.73			136.22		119.95

(a) Costs are from Table 6.1
(b) Assumes trenching used to collect contaminated ground water

Percent of operating period	Monitoring frequency schedule	Samples (analyses) per year
10	daily	730
20	3 days/week	312
30	weekly	104
20	semimonthly	48
20	monthly	24

and that the analysis cost per sample would be $600. For a treatment plant operating 10 years, the total number of samples would be 730 + 624 + 312 + 96 + 48 = 1810 and the estimated cost of monitoring would be $1,086,000 at $600 per sample. The total estimated monitoring cost for the 17 plants operating for various periods would be $23 million. This cost at a 5% present worth rate is about $17 million and at 10%, is about $13 million.

6.5.2 Estimated monitoring costs of ground water

Monitoring of the contaminated ground water consists of collecting ground water from wells that terminate in the uppermost aquifer and any other aquifers that are hydraulically connected to the uppermost aquifer. The number of wells must be sufficient to adequately define the contaminated plume. Guidance is available for estimating the number of wells (EPA 86), but for these cost estimates the number of wells already in use is used. For those sites where no information is available, the average of 25 wells per site is used.

Frequency of sampling is quarterly, consistent with the 40 CFR 264.99 rule. The cost of analyzing each sample is $600 (DOE 88b). The length of time that compliance monitoring must be conducted is assumed to be during the operating period of the treatment and for a 5-year period after standards are achieved in ground water (after shutdown of the treatment plant). These times vary from 10 years to 58 years in these estimates.

The total estimated cost of monitoring ground water is $21 million at the 17 sites that DOE currently identifies as requiring ground-water restoration. The estimated present value of ground-water monitoring at a 5% rate is about $11 million and at a 10% rate, is about $8 million.

6.6 TOTAL ESTIMATED COSTS

The total estimated cost for ground-water restoration including monitoring is $214 million at the 17 sites that DOE currently projects require restoration. The cost of ground-water monitoring is estimated by DOE (DOE 88c) as $24 million at the remaining 7 sites. The grand total for all 24 sites is then about $240 million. The present worth of this grand total at 5% is about $190 million. The present worth of the grand total at 10% is about $160 million.

Using a combination of cleanup and natural cleansing will also reduce costs. In this instance, partial cleanup, which appears to be most efficient (see Section 6.2), is performed to reduce contamination to levels that will be cleansed by natural processes within the extended remedial period limit. This can significantly reduce costs by reducing the amount of water requiring processing to perhaps two or three times the contaminated volume (rather than five times). The implementation of institutional controls is not costly.

Costs could also be reduced if permission could be obtained to discharge contaminated ground water to rivers or to land treatment (land farming) facilities (e.g., Christmas tree farm), rather than treat it. For example, if the uranium concentration is less than 2 mg per liter, which is the effluent limitations guidelines for the discharge of waste water from uranium mines (40 CFR 440), and if all other numerical limits in the guidelines and BADT requirements are met, it appears it may be possible to discharge the contaminated water to a river. Likewise, it may be possible to discharge contaminated ground water to land treatment facilities provided that the requirements of 40 CFR 268 are met. However, these possibilities are site specific to the extent that cost cannot be estimated on a generic basis.

6.7 REVIEW OF DOE COST ESTIMATES

6.7.1 DOE Cost Estimates

DOE submitted comments on the proposed rule during January 1988. These included an appendix presenting cost estimates for restoration and monitoring of contaminated ground water (DOE 88a). During May 1988, DOE provided EPA with additional cost estimates that were called "Attachment A Reestimation of Aquifer Restoration Costs" (DOE 88b). Further, DOE submitted a report entitled "U.S. Department of Energy Final Response to Standards for Remedial Actions at Inactive Processing Sites" during November 1988 which included a table with an estimated groundwater restoration project cost (DOE 88c).

The DOE January 1988 estimate was based on information on the extent of groundwater contamination at five sites. These estimates were then extrapolated to all 24 sites using a "similar site" approach. The total volume to be pumped and treated or discharged was estimated by adding to the current contaminated water volume, the volume that would be needed to flush 10% of the contaminants that are adsorbed on soils. DOE estimated the base cost as $746 million. DOE applied a "project factor" of 2.3 to obtain their total cost estimate of $1,715 million.

The DOE May 1988 submittal included nine additional cost estimates. The base cost for restoring ground water at all 24 sites combined ranged from a total of $393.71 million to $745.68 million. For some of these estimates, DOE reduced the "project factor" from 2.3 to 1.424 and reduced the estimate for one site as discussed below, yielding a new total cost range of $560.65 million to $1,715.07 million.

The DOE November 1988 submittal included an estimated project base cost of $664 million and an estimated base plus contingency cost of $760 million, both in 1989 dollars. This report also provided an escalated project cost of $985 million after applying standard federal escalation rates through 1994 with no escalation beyond 1994.

6.7.2 Evaluation of DOE Cost Estimates

In the DOE January 1988 estimate, one site, Falls City, Texas, accounts for 47% ($348 million of $746 million) of the total base cost. The volume of contaminated ground water at Falls City is large. The principal hazardous contaminants are uranium, molybdenum, chromium, nitrate, and radium-226. In fact, the estimated mass of uranium-contaminated ground water at Falls City is 98% of the total mass from all 24 sites. Also, the quantity of uranium adsorbed on soil is among the four greatest at the 24 sites. Likewise, the estimated mass of molybdenum in ground water is 93% and of chromium is 95% of the total from all 24 sites.

In the DOE May 1988 material, the costs were reestimated by varying 3 different factors: the number of water treatment plants needed at the Falls City site, the monitoring frequency of ground water and of the inflow and outflow of the water treatment plant, and the project factor. The results of this reestimation are summarized in Table 6-3.

A large reduction in costs is achieved by using one treatment plant at Falls City instead of three. Four different aquifers are contaminated at Falls City. In the initial estimate DOE extrapolated cost estimates from other sites, including a treatment plant for each of the three major contaminated aquifers (the contaminated water from the fourth aquifer was to be treated at one of these three). Since the cost of extracting ground water at Falls City is low (it can all be done by trenching), the major costs are for installing, operating, and monitoring the treatment plants. In fact, almost 95% of the cost is associated with these tasks. The reason for the high operating and monitoring costs is the projected 80 to 100 years that the treatment plants will have to operate.

Table 6-3 Summary table - Aquifer restoration costs (DOE 88b)

Option	Cost (Millions $)	
	Base	Project
Current*	745.68	1,715.07
1	393.71	905.54
2	538.44	1,238.41
3	593.60	1,365.28
4	453.73	1,043.58
5	745.68	1,061.85
6	393.71	560.65
7	538.44	766.74
8	593.60	845.29
9	453.73	646.11

where:

Option	Number of treatment plants at Falls City	Plant sampling frequency	Well sampling frequency	Project factor
Current*	3	daily	daily	2.3
1	1	schedule A	schedule C	2.3
2	3	schedule A	schedule C	2.3
3	3	schedule B	schedule C	2.3
4	1	schedule B	schedule C	2.3
5	3	daily	daily	1.424
6	1	schedule A	schedule C	1.424
7	3	schedule A	schedule C	1.424
8	3	schedule B	schedule C	1.424
9	1	schedule B	schedule C	1.424

where schedules are presented in percentage of the restoration or monitoring time which varies from site to site. For example, if restoration is estimated to take 10 years, under schedule A sampling would occur on a daily basis for 1 year, on a 3 day per week basis for 20 years, on a weekly basis for 3 years, on a semimonthly basis for 2 years and on a monthly basis for 2 years.

Schedule A	
Daily	10%
3 days/week	20%
Weekly	30%
Semimonthly	20%
Monthly	20%

Schedule B	
Daily	20%
3 days/week	30%
Weekly	20%
Semimonthly	30%

Schedule C	
Quarterly	20%
Annually	70%
Quarterly	10%

*DOE 88a

Only one treatment plant is needed at Falls City. The contaminated ground water extends less than three miles and can be pumped inexpensively to a central treatment plant. Use of one plant instead of three reduces construction costs from $28 million to $10 million, operating costs from $179 million to $63 million, and monitoring costs from $123 million to $44 million. Reducing the plant monitoring schedule from daily to monthly gradually over the 100-year operating period further reduces monitoring costs from $44 million to $11 million. When the reduced monitoring schedule is extended to all sites, the low end of the range of the total base cost estimate is $394 million.

The "project factor" reflects the difference in cost between industry doing the job and the government (DOE) doing the job. Although the 1.424 factor appears more reasonable than the 2.3 factor, especially considering the routine nature of the job, it is not clear that EPA is required to consider this additional cost in promulgating standards. Basically, the cost of actively restoring ground water quality at all 24 sites, according to DOE estimates, is $394 million. However, DOE has identified 7 sites that will not require active restoration. This is consistent with EPA's projection in the draft BID (EPA 87). Reducing the DOE base cost by the active restoration costs for these 7 sites results in a total estimated base cost of $325 million. This cost estimate includes monitoring costs over a period that extends to 100 years at some sites. This estimate can then be compared to EPA's cost estimate of $240 million (see Table 6-1 and Section 6.5).

A comparison of DOE and EPA total cost estimates is presented in Table 6-4. The low estimate from the May 1988 DOE submittal is used since this appears to be the most reasonable estimate. The estimated costs for ground-water monitoring at the 7 sites where cleanup is unlikely are from the November 1988 DOE submittal. The EPA costs are from Table 6.1. The two estimated total costs are within about 30% of each other, which is acceptable agreement, given the preliminary nature of the data.

DOE appears to use unusual conservatism in estimating some of these costs for ground-water restoration. An example of this is found in the estimate for the Falls City site. The latest DOE projection indicates it will take 53 years to restore the ground water at Falls City using a treatment plant with a capacity of 100,000 gallons per day (DOE 88c). DOE estimates the installed cost of a treatment plant of this size to be $2 million. With an assumed plant lifetime of 20 years, 3 new plants are assumed to be needed over the 53-year restoration period, for a total installation cost of $6 million. The EPA estimate for the total installed cost of 3 treatment plants is $1 to $2 million, after increasing 1975 costs by a factor of 3 to account for inflation (EPA 77). Operating the treatment plant for 53 years is estimated by DOE to cost $33 million. This may be compared to EPA's estimate of operating costs of $11 million (EPA 77). The

Table 6-4 Comparison of DOE and EPA Cost Estimates for Restoration of Ground Water at the Inactive Uranium Mill Tailings Sites

Site	DOE estimates			EPA cost estimates ($M)
	Similar site	Base cost (DOE 88b) ($M)	Monitoring cost only (DOE 88c) ($M)	
Ambrosia	Lakeview	25.58		7.74
Belfield	Lakeview		2.8	
Bowman	Lakeview		3.8	
Canonsburg	Riverton	8.32		2.38
Durango	Gunnison	8.50		5.31
Falls City	Falls City	103.02		46.71
Grand Junction	Riverton	5.98		6.98
Green River	Lakeview		3.8	
Gunnison	Gunnison	18.3		20.67
Lakeview	Lakeview	9.8		30.51
Lowman	Lakeview		2.8	
Maybell	Tuba City	4.7		2.93
Mexican Hat	Tuba City		2.8	
Monument Valley	Tuba City	20.6		33.56
Naturita	Riverton	4.2		1.95
Rifle - old	Riverton		3.8	
Rifle - new	Riverton	3.93		7.01
Riverton	Riverton	14.53		10.82
Salt Lake City	Riverton		3.8	
Shiprock	Riverton	6.04		11.77
Slick Rock - NC	Riverton	3.88		1.39
Slick Rock - UC	Riverton	4.16		1.34
Spook	Tuba City	40.92		7.48
Tuba City	Tuba City	18.68		15.36
Totals		301	23.6	214

primary cause of this difference is due to the size of the operating crew, estimated as 15 person-days per day by DOE and as 4 person-days per day by EPA. We do not believe it is necessary to maintain a full crew for all three 8-hour shifts. One is sufficient for two of these, since repairs and manpower intensive maintenance can be scheduled for a normal daytime workday shift.

6.8 REVIEW OF TOTAL URANIUM VALUE

An estimate of the total value of the uranium produced at the inactive sites was made to provide a perspective on the costs of remediation of ground water contamination. The total quantity of tailings at the inactive sites is about 25 million tons (see Chapter 3). The average uranium content of the ore was estimated to be 0.25%. We were unable to determine the price actually paid for uranium at these inactive sites. However, uranium production and prices were summarized by DOE in their 1982 report on commingled uranium tailings (DOE 82). The report contains data for the licensed, or to be licensed, sites that were operating during the 1949 through 1971 period, including the quantity of uranium purchased and the purchase price. Most of the uranium from these sites was purchased in the 1960s. It is reasonable to assume that uranium from the inactive sites was purchased earlier or in any case no later than that from the licensed sites. Based on this data and assuming a mean year of production of 1965, the price of the uranium varied over a narrow range with a mean of about 10 dollars per pound.

Using the above values, it is estimated that the value of uranium produced at the inactive sites was $1.2 billion 1965 dollars. Using the producer price index for crude materials for further processing (GPO 89) to escalate this value to the estimated 1989 value yields $3.9 billion. The estimated present value of the cost of cleanup of the ground water at the inactive sites is $214 million, or less than 6% of the total value of the uranium produced at these sites, in constant dollars.

6.9 REFERENCES

DOE 82 Commingled Uranium Tailings Study, DOE/DP-0011, U.S. Department of Energy, Washington, D.C. 20545 (June 1982).

DOE 88a U.S. Department of Energy, letter to EPA docket, number R-87-01, from Theodore J. Garrish, Assistant Secretary for Nuclear Energy, January 26, 1988.

DOE 88b U.S. Department of Energy, material provided to Tom Loomis, EPA contractor, entitled "Attachment A, Re-estimation of Aquifer Restoration Costs, May 17, 1988."

DOE 88c U.S. Department of Energy, "Final Response to Standards for Remedial Actions at Inactive Uranium Processing Sites," November 1988.

EPA 77 U.S. Environmental Protection Agency, "Costs of Radium Removal from Potable Water Supplies," EPA-600/2-77-073. Municipal Environmental Research Laboratory, Office of Research and Development, U.S. EPA, Cincinnati, Ohio 45268.

EPA 86 U.S. Environmental Protection Agency, "RCRA Ground Water Monitoring Technical Enforcement Guidance Document (TEGD)," OSWER-9950.1, September 1986.

EPA 87 U.S. Environmental Protection Agency, "Ground-Water Protection Standards for Inactive Uranium Tailings Sites - Background Information for Proposed Rule," EPA 520/1-87-014, Office of Radiation Programs, Washington, D.C. 20460.

GPO 89 Economic Report of the President, U.S. Government Printing Office, Washington, D.C. (January 1989).

NUREG86 U.S. Nuclear Regulatory Commission, "An Analysis of Excursions at Selected In Situ Uranium Mines in Wyoming and Texas," NUREG/CR-3967 (ORNL/TM-9956), 1986.

CHAPTER 7

OTHER CONSIDERATIONS

7.1 CONCENTRATION LIMITS FOR MOLYBDENUM, URANIUM, RADIUM AND NITRATES

Molybdenum, uranium, radium and nitrates have been found in tailings and in ground water that is contaminated by tailings. While these substances have not been listed as hazardous under the Resource Conservation and Recovery Act (RCRA), which amended the Solid Waste Disposal Act (SWDA), they have been identified as hazardous or controlled in other EPA rules using different authorities. However, quantitative limits that are useful for this rulemaking have not, as yet, been determined for uranium and molybdenum. The proposed concentration limits for each of these four substances are discussed in this section.

7.1.1 Molybdenum

Molybdenum was added to the hazardous constituents for the licensed tailings since it was found in high concentrations at some sites and had caused molybdenosis in cattle (48FR45926, Do72). No concentration limit was established at that time, however, because only sparse data were available on human toxicity. Listing molybdenum, but not issuing a concentration limit, means it must be controlled to background levels, to be consistent with RCRA standards.

A concentration limit of 50 ppb was proposed for molybdenum in the proposed standards for inactive tailings (46FR2556). This proposed groundwater standard was not promulgated, however, because as stated in the Federal Register notice, "We do not believe that the existing evidence indicates that ground water contamination from inactive mill tailings is or will be a matter of regulatory concern" (48FR590). The Court remanded this to the Agency in 1985.

The Agency has proposed National Primary Drinking Water Regulations for Inorganic Chemicals, among others (50FR46936). While the Agency decided not to propose a Recommended Maximum Concentration Limit (RMCL) [This is now being called a Maximum Concentration Limit Goal (MCLG).] for molybdenum because of inadequate data on toxicity of the compound, a provisional adjusted acceptable daily intake (AADI) was determined. This provisional AADI was based upon an epidemiological study in which only one dose was examined and no effects were noted.

The Agency asked for comments on the question, "Should a Health Advisory be developed for molybdenum or is there sufficient health effects information upon which to base an RMCL?" While the Agency has not made a final decision on molybdenum, it appears unlikely that a Health Advisory will be issued for molybdenum based on the NAS consideration (NAS80) that molybdenum in drinking water, except from highly contaminated sources (molybdenum mining waste water), is not likely to constitute a significant portion of the total human daily intake of the element.

An analysis of toxic substances in tailings was included in the Final EIS for Remedial Action Standards for Inactive Uranium Processing Sites (EPA82), Appendix C. This analysis included consideration of molybdenum in tailings and of molybdenum toxicity in humans, livestock, and crops.

Molybdenum in tailings is found at levels greater than 100 times its levels in typical or local soils. Uranium, selenium, arsenic, and vanadium are the only other metallic elements found at similarly high levels. However, data show wide variations of element concentrations among different piles. The ratio of an element's concentration in tailings to that in the soil surrounding the tailings is a measure of both its potential hazard and its potential for contaminating ground water.

Molybdenum is essential in trace quantities for human nutrition. There are no data for acute toxicity of molybdenum following ingestion by humans, but the animal data (Ve78) show that toxicity results from intakes of around hundreds of milligrams per kilogram of body weight.

Chronic toxicity symptoms have been reported in 18 percent to 31 percent of a group of Armenian adults who consumed 10 to 15 milligrams of molybdenum per day and in 1 percent to 4 percent of a group consuming 1 to 2 milligrams of molybdenum per day (Cha79), (NAS80). Clinical signs of the toxicity were a high incidence of a gout-like disease with arthralgia and joint deformities, and increased urinary excretion of copper and uric acid. Increased urinary copper excretion has been observed in persons who consumed 0.5 to 1.5 milligrams of molybdenum per day and in persons drinking water containing 0.15 to 0.20 ppm of molybdenum but not in persons drinking water containing up to 0.05 ppm of molybdenum (Cha79). The significance of the increased copper excretion is not known. Recent reports have associated molybdenum deficiency and esophageal cancer (Lu80a,b). Until these reports are confirmed and evaluated, the minimum molybdenum requirements are uncertain.

The ratio of toxic intake to the recommended daily allowance for humans is narrow for molybdenum, ranging from 10 to 40 (NAS80). Using the NAS80 value for Adequate and Safe Daily Intake of 0.15 to 0.50 mg and this ratio leads to an estimated potentially toxic daily intake of 2 to 20 mg of molybdenum,

In livestock, estimates of molybdenum concentrations leading to toxicity were made for both ruminants and nonruminants. The most critical receptor for molybdenum in the water pathway was dairy cattle, because of the large water consumption of lactating cows. The estimated concentration of molybdenum in water that is potentially toxic to dairy cattle is 0.51 to 2.6 ppm (EPA82). This led to a recommended maximum concentration of molybdenum in water of 0.05 ppm (EPA82).

In crops, estimates were made of molybdenum concentrations in irrigation water that might be toxic to agricultural crops grown using such water. Based on an NAS publication (NAS72), irrigation water at 1 ppm molybdenum could be immediately toxic to crops if the irrigation water is applied at 3-acre foot per acre per year (8.13 lbs of molybdenum per acre per year).

7.1.2 Uranium

The National Interim Primary Drinking Water Regulation (40CFR141, EPA76) provide no maximum contaminant level (MCL) for uranium. In fact, uranium along with radon is explicitly excluded from the MCL for gross alpha particle activity (40CFR141) which is 15 pCi per liter. These were excluded because data were inadequate to determine if there was a need for such regulations (i.e., the levels of uranium and radon in water were not well-known) and the cost of removal of uranium and radon from drinking water was not established. The Agency has issued an advance notice of proposed rulemaking (51FR34836) stating that MCLGs and MCLs are being considered for radium-226, -228, natural uranium, radon, gross alpha, and gross beta and photon emitters.

At the uranium mill tailings sites, natural uranium is present and consists of three isotopes, ^{234}U, 0.0057% abundance by weight; ^{235}U, 0.7196% abundance; and ^{238}U, 99.276% abundance. Their half-lives are, respectively, 2.47×10^5 years, 7.1×10^8 years, and 4.51×10^9 years. Each decays by emitting an alpha particle; uranium-234 and 235 also emit gamma rays. Although uranium-238 is the most abundant isotope in natural uranium by weight, it accounts for only half of the total radioactivity of natural uranium.

Uranium can damage human health two ways, chemically and radiologically. Uranium ingested above a certain concentration is chemically toxic to humans and thus has a threshold below which chemical toxicity does not exist. The National Academy of Sciences (NAS 83) reviewed the toxicity level of uranium and issued a suggested No-Adverse-Response Level (SNARL) of 35 ppb (23 pCi/l) for chronic exposure. The NAS report states, "Because of its low specific activity, natural uranium dose not pose a problem of radiotoxicity in drinking water. Assessment of uranium toxicity in drinking water should be based on its chemical toxicity and not on radiation toxicity. However, when the specific activity of uranium in drinking water has been altered so that it is greater than that of natural uranium, potential radiotoxicity should be given attention equal to that of the chemical toxicity. The committee also recommends that toxicological assessment of uranium in water be based solely on its renal toxicity in all instances except when industrial processes result in a marked enrichment of shorter-lived uranium isotopes."

Radiotoxcity can be the basis for establishing a limit for uranium in drinking water by using the recommendations of the International Commission on Radiological Protection (ICRP 78). By allowing the same level of risk for uranium as for radium (0.7 to 3.0 fatal cancers per year per million persons exposed) a natural uranium concentration limit of 23 pCi/l is calculated by using ratios of the ICRP annual limits on intake (ALIs) for stochastic (non-threshold) effects. Using the ICRP ALIs for nonstochastic (toxic) effects for protection of workers yields a natural uranium concentration limit of 30 pCi/l, assuming the same risk from uranium as from radium. This approach, therefore leads to limits for natural uranium in drinking water that are, for all practical purposes the same as the NAS recommended limits.

A review of the uranium concentrations in ground water at the 14 sites for which data are available (see Chapter 4) is presented in Table 7.1. This review indicates that when uranium contamination of ground water occurs at uranium mill sites concentrations of uranium increase substantially. Large percentages of the ground water samples that were measured for uranium exceed 100 pCi/l at most sites. Based on these limited data, ground water is contaminated at 12 of the 14 sites at either the 30 pCi/l or the 100 pCi/l limit. From this it can be concluded that the choice of a limit in the range under consideration (10 to 100 pCi/l) will not make a difference in determining whether or not ground water is contaminated at a site. However, the choice of a limit may make a difference in the extent of cleanup of ground water, should cleanup be necessary.

Table 7.1 Summary of Uranium Concentrations in Ground Water at Inactive Uranium Mill Tailing Sites

Site	Number of Samples Analyzed for Uranium (a)	Percent of Samples Greater Than 15 ppb (b)	44 ppb	150 ppb
Ambrosia Lake	30	77	60	47
Canonsburg	55	49	40	35
Durango	64	78	45	20
Grand Junction	140	79	74	31
Green River	156	47	37	30
Gunnison	59	64	42	32
Lakeview	70	4	1	1
Mexican Hat	15	53	47	40
Monument Valley	57	18	0	0
Rifle	34	94	82	47
Riverton	26	92	88	73
Salt Lake City	81	51	37	21
Shiprock	19	95	79	68
Tuba City	15	100	87	53

(a) For some sites samples are from both down gradient and background aquifers. For other sites samples are from known contaminated ground water. No conclusions should be drawn from these data regarding the need for cleanup.

(b) 1.47 ppb = 0.00147 mg/l = 1 pCi/l

7.1.3 Radium

Radium is present in mill tailings at levels in the hundreds of pCi per gram range and has been found in elevated concentrations in ground water near tailings sites. The National Interim Primary Drinking Water Regulation for radium is 5 PCi per liter combined radium-226 and radium-228. Since the standards are required by UMTRCA to be consistent with RCRA standards and since RCRA standards have adopted drinking water regulations as standards for ground water, the same procedure is used in this rulemaking. Thus, the standard for radium is 5 pCi per liter combined radium-226 and radium-228.

7.1.4 Nitrates

Nitrates have been found in elevated concentrations in ground water near tailings piles. The National Interim Primary Drinking Water Regulation for nitrates is 10 mg per liter as nitrogen. Using the same rationale as above for radium, the standard for nitrates is 10 mg per liter as nitrogen.

7.2 INSTITUTIONAL CONTROL

The Agency has been considering institutional control for over ten years. Public workshops and a public forum were conducted in 1977 and 1978 to develop insight for the objectives of radioactive waste disposal (EPA77a, EPA77b, EPA78). These efforts resulted in 1978 with the publication of proposed Criteria for Radioactive Wastes: Recommendations for Federal Radiation Guidance (43 F.R. 53262). The subject of institutional control was a major factor in these recommendations:

"Proposed Criterion No. 2. The fundamental goal for controlling any type of radioactive waste should be complete isolation over its hazardous lifetime. Controls which are based on institutional functions should not be relied upon for longer than 100 years to provide such isolation; radioactive wastes with a hazardous lifetime longer than 100 years should be controlled by as many engineered and natural barriers as are necessary." And,

"Proposed Criterion No. 6. Certain additional procedures and techniques should also be applied to waste disposal systems which otherwise satisfy these criteria if use of these additional procedures and techniques provide a net improvement in environmental and public health protection. Among these are: a. Procedures or techniques designed to enhance the retrievability of the waste; and b. Passive methods of communicating to future people the potential hazards which could result from an accidental or intentional disturbance of disposed radioactive wastes."

These proposed criteria were further discussed:

"Issue No. 2. Control of Radioactive waste. The management of radioactive wastes represents potential exposure of individuals and populations and the possible contamination of the general environment. These potential impacts require definitive controls to be established. Further, because of the trustee responsibility each generation has to succeeding ones, contamination of the general environment should be avoided regardless of whether humans will actually contact the waste directly. It is important to prevent both human and environmental adverse impacts. Therefore, the fundamental goal for controlling any type of radioactive waste should be complete isolation over its hazardous lifetime.

"Controls for radioactive wastes are of three general types: Engineered barriers, natural barriers, and institutional mechanisms. Engineered barriers such as containers or structures generally can be considered only as interim measures for containment, despite the fact that some structures have survived intact through the ages. Stable geologic media are an example of natural barriers. Institutional controls are those which depend on some social order to prevent humans from coming in contact with wastes, such as controlling site boundaries, guarding a structure, land use policies, record-keeping, monitoring, etc.

"It generally is accepted that long-term isolation should depend on stable natural barriers. Institutional mechanisms, which are essential in the early stages of management of any waste, are short-term processes because of practical limitations. Institutional means can be very effective in isolating radioactive wastes from humans if they can be maintained. Since society's basic structure and concern about waste may change, it is reasonable to rely on such controls for only limited periods.

"The choice of a time period for relying on institutional control is completely a matter of judgment, but is basic to a determination of when use of such controls is proper. During the developmental stages of this criteria document, it was proposed that 100 years should be the maximum time period for such controls to be depended upon with any degree of assurance. The public forum participants recommended deleting the time period because it appeared to be arbitrary; however, they left the issue unaddressed in any other form.

"Because there are a number of current mechanisms for disposing of various types of wastes which are based on institutional care, the Agency believes that guidance is required to assure that institutional controls are relied upon only to the extent they are appropriate. There are numerous types of radioactive wastes of such hazard potential that they will require the adoption of stricter control methods than currently practiced and will require the development of new disposal technologies which will assure better isolation [than] that afforded by institutional control mechanisms. For this reason, when disposal decisions are made they should recognize that institutional controls are only of limited use, and if the wastes will be hazardous longer than 100 years, other means of control will need to be found.

"This means that in selecting control options for wastes whose hazards extend beyond 100 years decisions makers cannot rely on restrictions on customary uses of land and of ground or surface waters. This does not mean that institutional controls are required for 100 years, or that they must stop at that point if society can still maintain them; only that people making the initial disposal decision should not plan on their use to maintain protection beyond 100 years. The judgment that 100 years is the most appropriate time interval will be further examined throughout the public comment period."

"<u>Issue No. 6 Supplementary Protection Goals</u>. A number of other subjects pertinent to protection of the public from radioactive wastes were discussed in the development of the criteria. Among these, most attention centered on monitoring, provision of retrievability, and passive communication of the nature of the possible hazard to future generations. In general, it was determined that, while each has positive aspects for control of radiological hazards, their application might undermine the goal of providing permanent isolation for wastes. It is difficult to maintain retrievability or conduct a monitoring program without compromising the ability to provide isolation. Furthermore, in many disposal situations which will satisfy the five criteria discussed above, the residual risk will mainly be attributable to potential failure mechanisms involving eventual intrusion by humans. Passive methods of communicating the hazard, such as markers which call attention to the waste, may sometimes be judged to provide a net reduction of risk. Other passive methods, such as creating records describing the waste, or setting aside of the land title to the disposal site, have value in reducing the likelihood of intrusion for some limited time.

"An example of a circumstance where land title transfer is reasonable is a current site that has been in use for some time where optimal environmental isolation is no longer a practicable alternative, such as an abandoned mill tailings site, a nuclear test facility site, etc. In these cases, Federal ownership of the land beyond the normal period of institutional control would be reasonable to minimize potential intrusion. Such decisions should be made on a case-by-case basis and provision for specifically treating such exceptions should be addressed in standards and regulations which are promulgated for these types of wastes.

"It is not appropriate to depend upon methods such as these or other similar ones for long-term control; nonetheless, when such methods would enhance overall protection from wastes, it is prudent to use them. This is particularly the case for retrievability and passive communication. Monitoring was judged by the Public Forum participants to be generally a part of early institutional controls prior to completion of disposal, and thus it is not included in the criterion for supplementary controls."

While these criteria were never enacted in final form, they served as the basis for the assurance requirements (40 CFR 191.14) which the Agency issued as final standards in 1985: Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes 50 F.R. 38066. These standards culminated the above consideration of institutional control in this context. Specifically:

> 40 CFR 191.14 (a) Active institutional controls over disposal sites should be maintained for as long a period of time as is practicable after disposal; however, performance assessments that assess isolation of the wastes from the accessible environment shall not consider any contributions from active institutional controls for more than 100 years after disposal.
>
> (b) Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring.
>
> (c) Disposal sites shall be designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers of the wastes and their location.

Where the following terms are defined as:

40 CFR 191.12 (a) "Disposal system" means any combination of engineered and natural barriers that isolate spent nuclear fuel or radioactive waste after disposal.

(d) "Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides toward the accessible environment. For example, a barrier may be a geologic structure, a canister, a waste form with physical and chemical characteristics that significantly decrease the mobility of radionuclides, or a material placed over and around waste, provided that the material or structure substantially delays movement of water or radionuclides.

(e) "Passive institutional control" means: (1) Permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system.

(f) "Active institutional control" means: (1) Controlling access to a disposal site by any means other than passive institutional controls; (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance.

And the following guidance for implementation is given:

40 CFR 191 Appendix B <u>Institutional Controls</u>. To comply with section 191.14(a), the implementing agency will assume that none of the active institutional controls prevent or reduce radionuclide releases for more than 100 years after disposal. However, the Federal Government is committed to retaining ownership of all disposal sites for spent nuclear fuel and high-level and transuranic radioactive wastes and will establish appropriate markers and records, consistent with section 191.14(c). The Agency assumes that, as long as such passive institutional controls endure and are understood, they: (1) can be effective in deterring systematic or persistent exploitation of these disposal sites; and (2) can reduce the likelihood of inadvertent, intermittent human intrusion to a degree to be determined by the implementing

agency. However, the Agency believes that passive institutional controls can never be assumed to eliminate the chance of inadvertent and intermittent human intrusion into these disposal sites.

The statement of considerations for this regulation (50 F.R. 38066) includes the following discussion:

"Approach Toward Institutional Controls. The Agency particularly sought comment on its proposed approach to reliance on institutional controls. The proposed rule limited reliance on 'active institutional controls' (such as controlling access to a disposal site, performing maintenance operations, or cleaning up releases) to a reasonable period of time after disposal, described as on the order of a 'few hundred years.' On the other hand, 'passive institutional controls' (such as permanent markers, records, archives, and other methods of preserving knowledge) were considered to be at least partially effective for a longer period of time.

"Few commenters argued with the distinction between active and passive institutional controls, or with the amount of reliance the proposed rule envisioned for passive controls. However, many commenters felt that 'a few hundred years' was too long a period to count on active controls. Accordingly, the final rule limits reliance on active institutional controls to no more than 100 years after disposal. This was the time period the Agency considered in criteria for radioactive waste disposal that were proposed for public comment in 1978 (43 F.R. 53262), a period that was generally supported by the commenters on that proposal. After this time, no contribution from any of the active institutional controls can be projected to prevent or limit potential releases of waste from a disposal system.

"The concept of passive institutional controls has now been incorporated into the definition of 'controlled area' that is used to establish one of the boundaries for applicability of the containment requirements and the individual protection requirements in the final rule. Because the assumptions made about the effectiveness of passive institutional controls can strongly affect implementation of the containment requirements, the Agency's intent has been elaborated in the "guidance for implementation" section. The Federal Government is committed to retaining control over disposal sites for these wastes as long as possible. Accordingly (and in compliance with one of the assurance requirements), an extensive system of explanatory markers and records will be instituted to warn future generations about the location and dangers of these wastes. These passive controls have not been assumed to prevent all possibilities of inadvertent human intrusion, because there will always be a realistic chance that some individuals will over look or misunderstand the markers and records. (For example, exploratory drilling operations occasionally intrude into areas that clearly would have been avoided if existing information had been obtained and properly evaluated.) However, the Agency assumed that society in general will retain knowledge about these wastes and that future societies should be able to deter systematic or persistent exploitation of a disposal site.

"The Agency also assumed that passive institutional controls should reduce the chance of inadvertent intrusion compared to the likelihood if no markers and records were in place. Specific judgments about the chances and consequences of intrusion should be made by the implementing agencies when more information about particular disposal sites and passive control systems is available. The parameters described in the "guidance for implementation" represent the most severe assumptions that the Agency believed were reasonable to use in its analyses to evaluate the feasibility of compliance with this rule (analyses that are summarized in the BID). The implementing agencies are free to use other assumption if they develop information considered adequate to support those judgments.

"The role envisioned for institutional controls in this rulemaking has been adapted from the general approach the Agency has followed in its activities involving disposal of radioactive wastes since the initial public workshops conducted in 1977 and 1978. The Agency's overall objective has been to protect public health and the environment from disposal of radioactive wastes without relying upon institutional controls for extended periods of time--because such controls do not appear to be reliable enough over the very long periods that these wastes remain dangerous. Instead the Agency has pursued standards that call for isolation of the wastes through the physical characteristics of disposal system siting and design, rather than through continuing maintenance and surveillance. The principle was enunciated in the general criteria published for public comment in 1978 (43 F.R. 53262), and it has been incorporated into the Agency's standards for disposal of uranium mill tailings (48 F.R. 590, 48 F.R. 45926).

"This approach has been tailored to fit two circumstances associated with mined geologic repositories. First, 40 CFR Part 191 places containment requirements on a broad range of potential unplanned releases as well as the expected behavior of the disposal system. Therefore, determining compliance with the standards involves performance assessments that consider the probabilities and consequences of a variety of disruptive events, including potential human intrusion. Not allowing passive institutional controls to be taken into account to some degree when estimating the consequences of inadvertent human intrusion could lead to less protective geologic media being selected for repository sites. The Agency's analyses indicate that repositories in salt formations have particularly good capabilities to isolate the wastes from flowing groundwater and, hence, the accessible environment. However, salt formations are also relatively easy to mine and are often associated with other types of resources. If performance assessments had to assume that future societies will have no way to ever recognize and limit the consequences of inadvertent intrusion (from solution mining of salt, for example), the scenarios that would have to be studied would be more likely to eliminate salt media from consideration than other rock types. Yet this could rule out repositories that may provide the best isolation, compared to other alternatives, if less pessimistic assumptions about survival of knowledge were made.

"The second circumstance that the Agency considered in evaluating the approach towards institutional controls taken in this rule is the fact that the mined geologic repositories planned for disposal of the materials covered by 40 CFR Part 191 are different from the disposal systems envisioned for any other type of waste. The types of inadvertent human activities that could lead to significant radiation exposures or releases of material from geologic repositories appear to call for much more intensive and organized effort than those which could cause problems at, for example, an unattended surface disposal site. It appears reasonable to assume that information regarding the disposal system is more likely to reach (and presumably deter) people undertaking such organized efforts than it is to inform individuals involved in mundane activities.

"These considerations led the Agency to conclude that a limited role for passive institutional controls would be appropriate when projecting the long-term performance of mined geologic repositories to judge compliance with these standards."

The Agency is continuing its consideration of institutional control with emphasis on its effectiveness. There is a need for guidance on the role for institutional control in developing corrective action policies for Subtitles C and D under the Resource Conservation and Recovery Act (RCRA), in designing the alternate concentration limit (ACL) program under RCRA, and in developing policies and achieving consistency for Superfund, especially in view of the Superfund Amendments and Reauthorization Act of 1986 (SARA).

Institutional controls can be ranked in terms of their effectiveness although it must be recognized that such ordering is not objective. There are many shifting perceptions about the effectiveness of each control, most of which are based on societal behavior. Nevertheless, the following ranking of institutional controls in roughly decreasing order of reliability may be useful in a broad, albeit arbitrary, context:

Monument (marble, granite, etc.)

Security program (guards and fences)

Government ownership

Government controlled easements on property adjacent to government-owned property

Restrictive covenant (deed restriction)

Deed notice

Professional licensing (licensing of well drillers)

Permitting programs (well construction permits)

Environmental standards (for well construction and location)

Water quality testing

Zoning (regulation of new development and property transactions)

Health advisories

The institutional controls with the greatest effectiveness are permanent and attention-gathering monuments, a security program involving guards, fences, etc., and government ownership. The second group involves land records and includes easements, deed restrictions, and deed notices. This second group is considered more effective than the third group since it involves less human activity and what human activity it does entail is primarily performed early (soon after a decision is made to use institutional controls). The third group includes regulatory/licensing actions similar to those applied to regulated operating activities. This third group involves more human activity than the second group. The fourth group involves a variety of general controls which are considered the least effective of this list.

There are three important points evident in this ranking. First, some of the institutional controls are active in that continuing actions are required by persons and some are passive in that no continuing actions are required by persons. Since active institutional controls are effective only as long as persons take action, selecting the period over which they retain effectiveness is crucial for health and environmental protection.

This timing question became the focus of the Agency's considerations of institutional control for providing protection from radioactive waste. There is no general consensus on the length of time human institutions will remain effective or reliable to continue such active measures. In this regard, failure of institutional controls does not necessarily imply a complete breakdown of societal structure. The more likely situation would be failure of institutional controls through program reductions, reorganization, changes in priorities, or through the failure of special funding mechanisms.

The timing question is most applicable to hazardous constituents at uranium mill sites since metals are the primary problem and no radioactive decay or organic decomposition takes place with metals. Dispersion of the metals in the ground water or adsorption in the aquifer matrix are the only natural cleansing processes.

Second, certain active institutional controls can be effective for as long as they last. A security program, for example, might well be the best institutional control method available for a short period. As such, active controls may be the best solution at a contaminated ground water site, if predictions of ground water cleansing by natural processes reliably project decontamination within a period during which the active institutional controls are highly effective. Another benefit of this approach is a reduction in both economic and environmental costs. An active institutional control solution is generally less expensive than a restoration program. Further, less environmental harm results from an active institutional control than from restoration activities. Restoration of ground water uses considerable energy and can contaminate large land areas for impoundments, processing plants, and associated appurtenances.

Third, institutional controls can be considered voluntary or involuntary, based on whether people comply with controls on their own accord or are forced to comply. A permanent marker is considered a voluntary control since it indicates the presence of hazardous wastes at a site but does not restrict actions which might disturb such wastes. A security program is considered an involuntary control since guards would prevent people from intruding into such wastes. Controls that prohibit new well construction or that prevent certain uses of the land can be voluntary or involuntary depending on the statutory authorities and implementing philosophy or practice of the local or state agency.

Institutional controls may be useful when combined with limited restoration of ground water quality. As discussed in Chapter 6, most of the decontamination appears to be achieved in the early stages of ground water pumping. If this initial efficiency of pumping is found to be the general case or can be reliably predicted, it may be feasible to combine limited pumping with institutional controls. This could be especially attractive if the initial pumping can reduce contaminant concentrations to levels where natural cleansing will reduce concentrations to standards levels within the life time of institutional controls.

Since wide variations exist in contamination and site characteristics and since local and state laws vary with regards to institutional control mechanisms, it is difficult to develop a generally applicable limit for a combined cleanup and institutional control effort. Nevertheless, it might be possible to establish a concentration limit at a particular site that is a few times the MCL and at which consideration of institutional control is warranted.

7.3 POST-REMEDIATION GROUNDWATER CONTAMINATION

Existing plumes of contaminated groundwater have been identified and evaluated at the various sites. These plumes have been characterized and estimates made as to both the time frame and efficacy of natural flushing to reduce the various contaminates to acceptable levels, either MCLs or, in some cases, background levels. Where it did not appear that these levels would be attained through natural flushing, estimates were made of the time and costs for alternative treatment of the contaminated groundwater. These estimates are presented elsewhere in this BID.

Following stabilization of the piles there are three possible mechanisms by which the tailings may serve as sources of new or continued contamination of the local groundwater: seasonal intrusions of local groundwater into the tailings piles, seepage of precipitation through the cover and the tailings, and drainage of moisture added during the remediation construction process to aid in tailings compaction during consolidation, relocating, and/or regrading of the piles. As discussed below, infiltration or seepage of precipitation into and through the tailings has been identified as the most serious long-term groundwater concern at the Title I UMTRA sites and designs for the pile covers are being evaluated on a site-specific basis to address this possibility.

7.3.1 Groundwater Intrusion

Studies identified groundwater intrusion as a potential problem at three sites: Grand Junction, Riverton, and Salt Lake City. The tailings have been relocated from the Salt Lake City site to Clive, the tailings at Riverton are in the process of being relocated to a Title II site, and it is planned to move the Grand Junction tailings to Cheney Reservoir site. Relocation of the tailings and contaminated soils will eliminate the source of contamination at the original site; care is taken in selection of alternate disposal sites and design of the disposal cells to avoid this problem at the new sites.(Ca88)

Groundwater intrusion is not considered to be a possibility at the sites identified for stabilization-in-place (SIP) or stabilization-on-site (SOS). At the SIP sites it has been determined that the base of the existing tailings pile is above the fluctuation range of the water table. At the SOS sites, where some or all of the tailings are to be relocated on the site, designs call for the tailings to be sited so that the base of the pile will be above the water table fluctuation range.

7.3.2 Precipitation

Precipitation which lands on the pile may infiltrate through the cover and the tailings, leaching contaminants from the tailings and carrying them into the groundwater thus augmenting groundwater contamination. Even though the average annual precipitation exceeds the average annual evaporation at all of the sites except Canonsburg, this has been identified as a concern because of the rock erosion barrier capping the piles. It appears that the unvegetated riprap or broken rock layer capping the pile and armoring the sides to prevent erosion will significantly reduce evaporation, allowing more infiltration.

Field studies carried out on completed piles at Clive and Shiprock, both sites having precipitation of about 6 inches annually, indicated that these piles are operating under unsaturated conditions. Measurement showed the compacted clay radon barrier to be operating at a hydrologic transmissivity in excess of 10^{-9} rather than the designed 10^{-7}. Measured conductivity ranged between 10^{-9} to 10^{-12} at Shiprock and 10^{-10} to 10^{-14} at Clive. At the Burrell vicinity property near Canonsburg, moisture levels remain at construction levels and the pile may be operating under saturated conditions with a hydrologic conductivity of 10^{-7} for the clay radon barrier. Additional field studies of the hydrologic conductivity of the clay layer are to be made at sites having precipitation of 10 to 16 inches annually.(Ti88)

7.3.3 Construction Water

During remediation work some water is added to the tailings and contaminated soil to control dust and assist compaction and grading as the tailings are consolidated on site or moved to another site. Subsequently, most of this added water will drain from the tailings carrying leached contaminants with it. This discharge of contaminated water will be a one-time "slug" occurring during and for a period after construction activities.

7.3.4 Construction of Final Cover

Originally, the pile cover was designed principally as a radon barrier, to control erosion, and to deter intrusion by vegetation and burrowing animals. Typical cover designs, shown in Figure 7.1, included a compacted clay and silt radon barrier, a sand bedding layer, and rock erosion barrier. The low-permeability radon barrier also served to limit significant infiltration. Pile covers similar to this design were installed at Shiprock, Clive, and Canonsburg and planned for Ambrosia Lake. Prior to publication of the EPA's proposed groundwater standards, similar pile and cover designs were

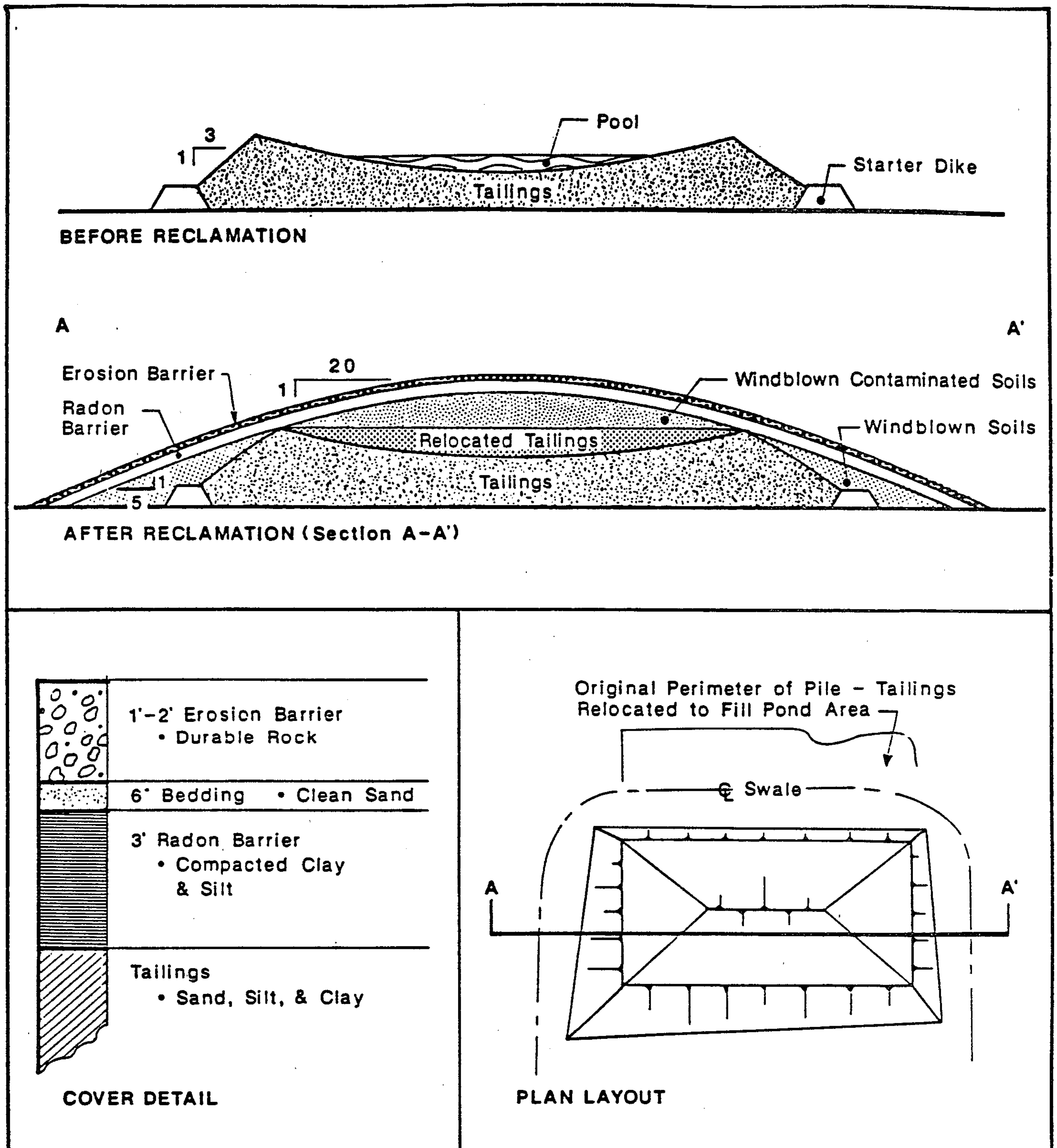


FIGURE 7-1
TYPICAL UMTRA PROJECT PILE LAYOUT

being considered for most of the other UMTRA Project sites. Construction had begun at Lakeview and Durango and was scheduled for Tuba City and Mexican Hat. Project designs were significantly advanced at Grand Junction, Belfield and Bowman, Falls City, and Slick Rock.

As a result of the EPA's proposed groundwater standards the DOE decided to relocate the tailings from the Monument Valley site to the Mexican Hat site; it was determined to be more economical to move the tailings than to stabilize them at Monument Valley. Also, the proposed standards have had a significant impact on the decision to relocate the Gunnison tailings to the Landfill site.

DOE has conducted a technology development program in conjunction with the UMTRA Project to develop standard practices for use in carrying out stabilization of the tailing piles. A number of special studies were undertaken as a consequence of the proposed groundwater standards, and revisions in the disposal pile and cover designs are under consideration. The studies focused on the use of geomembranes, alternate cover materials, alternate cover designs (including both composition and configuration), and disposal cell configuration. Figure 7.2 illustrates the various cover components now under consideration for use as appropriate on a site-by-site basis.

The following is a brief summary of the impact of the proposed groundwater standards on the various UMTRA Project sites.

-Ambrosia Lake: The hydraulic conductivity of the filter has been increased; no significant cost increase.

-Belfield/Bowman: Cover thickness has been increased to provide frost protection at a cost of about $400,000.

-Canonsburg: No impact; stabilization completed.

-Durango: Significant change in cover design.

-Falls City: Detailed evaluations have not been completed but it is expected that significant cell and cover design changes will be required to achieve compliance with the proposed groundwater standards.

-Grand Junction: New cover design formulated.

-Green River: Cover design modified by adding a frost protection layer and a higher permeability filter, and adding sodium bentonite to the radon/infiltration barrier to reduce permeability. Estimated additional cost is about $100,000.

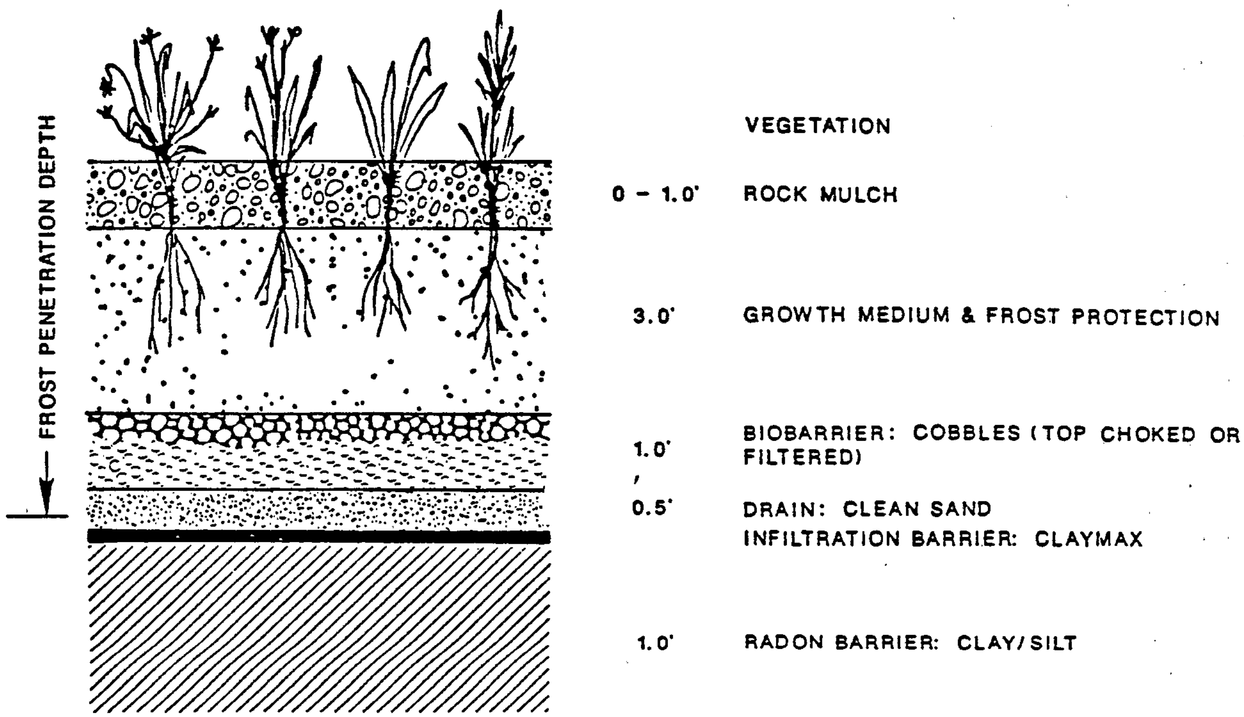


FIGURE 7-2
"CHECKLIST"
TOP COVER

-Gunnison: Tailings to be relocated to new site where the constrained cell with very low permeability cover will be constructed.

-Maybelle: Evaluation of design changes required to meet proposed standards has not been made; some changes in cover design may be needed.

-Mexican Hat: Material from Monument Valley will be incorporated at this site.

-Monument Valley: Tailings to be relocated to Mexican Hat site.

-Lakeview: No significant changes.

-Lowman: A frost protection layer may be added at a cost of $100,000.

-Naturita: The constrained cell design will probably be adopted.

-Riverton: No effect; the tailings are being relocated to a Title II facility.

-Rifle: A frost protection layer will be added to the cover at an estimated cost of $2 million.

-Salt Lake City: No impact; stabilization nearly complete at time proposed standards published.

-Shiprock: No impact; stabilization completed.

-Slick Rock: Detailed design reevaluations have not been done but a frost protection layer will probably have to be added; estimated cost is $125,000.

-Spook: A layer of CLAYMAX may be placed over the pile to facilitate demonstrating that ACLs are not required.

-Tuba City: The infiltration barrier will be placed at an hydraulic conductivity of 10^{-8}; on-site tests show that this is feasible.

The most significant impact on disposal cell design at individual UMTRA Project sites has been on the cover design; the realization that it is imperative to protect the infiltration barrier from the freeze/thaw cycle to maintain its low permeability and its ability to comply over the long-term with the EPA's proposed groundwater standards. The estimated total cost increase for adding frost protection is about $10 million.

Relocation of the Monument Valley tailings will cost about $10 million more than the previous design for stabilization on site. The revised cover designs at Durango, Grand Junction, Gunnison, Falls City, and Maybelle are roughly estimated to add about $1 million to the stabilization costs at each site.(Ca88)

7.4 REFERENCES

Ca88 Caldwell, J. A., R. Rager and N.B. Larson, "The Impact of Proposed EPA Groundwater Standards on UMTRA Project Disposal Cell Design," DOE Remedial Action Program Annual Meeting, Oct. 18-28, 1988.

Cha79 Chappell, W. R., et. al., "Human Health Effects of Molybdenum in Drinking Water," EPA600/1-79-006, 1979.

Do72 Dollahite, J. W., et. al., "Copper Deficiency and Molybdenosis Intoxication Associated with Grazing Near a Uranium Mine," The Southwestern Veterinarian, Fall 1972.

EPA76 Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," EPA 570/9-76-003, 1976.

EPA77a Environmental Protection Agency, Proceedings: A Workshop on Policy and Technical Issues Pertinent to the Development of Environmental Protection Criteria for Radioactive Wastes, ORP/CSD-77-1, 1977.

EPA77b Environmental Protection Agency, Proceedings: A Workshop on Policy and Technical Issues Pertinent to the Development of Environmental Protection Criteria for Radioactive Wastes, ORP/CSD-77-2, 1977.

EPA78 Environmental Protection Agency, Proceedings of a Public Forum on Environmental Protection Criteria for Radioactive Wastes, ORP/CSD-78-2, 1978.

EPA82 Environmental Protection Agency, "FEIS for Remedial Action Standards for Inactive Uranium Processing Sites (40 CFR 192)," EPA 520/4-82-013-1, Oct 82.

ICRP78 International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Pergamon Press, 1979.

Lu80a Luo, X. M., et. al., "Molybdenum and Esophageal Cancer in China," Southeast-Southwest Regional American Chemical Society Annual Meeting Abstracts, 40, 1980.

Lu80b Luo, X. M., et. al., "Preliminary Analysis of the Distribution of the Esophageal Cancer Mortality Rates," Geographical Environment and Chemical Elements in Food and Drinking Water in Anyang Administrative Region, Honan Province, Chinese J. Oncol. 2:74-80, 1980.

NAS72 National Academy of Science, "Water Quality Criteria, 1972," EPA-R3-73-033, NAS, Washington, 1972.

NAS80 National Academy of Science, "Drinking Water and Health, Volume 3," NAS, National Academy Press, Washington, 1980.

NAS83 National Academy of Science, "Drinking Water and Health, Volume 5," NAS, National Academy Press, Washington, 1983.

Ti88 Titus, Frank B., Jacobs Engineering Group, Inc., Oral presentation at DOE/NRC Hydrology Work Group Meeting, Albuquerque, NM, October 27, 1988.

Ve78 Venugopal, B. and T. D. Luckey, "Metal Toxicity in Mammals, Volume 2: Chemical Toxicity of Metals and Metoloids," Plenum Press, New York, 1978.