United States Department of Energy

TECHNICAL APPROACH FOR THE MANAGEMENT OF UMTRA GROUND WATER INVESTIGATION-DERIVED WASTES

February 1994

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Uranium Mill Tailings Remedial Action Project

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**TECHNICAL APPROACH FOR THE
MANAGEMENT OF UMTRA GROUND WATER
INVESTIGATION-DERIVED WASTES**

February 1994

**Prepared for
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LIST OF ACRONYMS AND ABBREVIATIONS

<u>Acronym</u>	<u>Definition</u>
AEA	Atomic Energy Act
CFR	Code of Federal Regulations
CWA	Clean Water Act
CWQA	Colorado Water Quality Control Act
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LLW	low level radioactive waste
mg/kg	milligram per kilogram
mg/L	milligram per liter
NMWQA	New Mexico Water Quality Act
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
OPCA	Oregon Pollution Control Act
pCi/g	picocurie per gram
pCi/L	picocurie per liter
POTW	Public Owned Treatment Works
RAC	Remedial Action Contractor
RCRA	Resource Conservation and Recovery Act
RRM	residual radioactive material
SOP	Standard Operating Procedure
TAC	Technical Assistance Contractor
TSCA	Toxic Substances Control Act
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
UWQA	Utah Water Quality Act
WEQA	Wyoming Environmental Quality Act

1.0 INTRODUCTION

During characterization, remediation, or monitoring activities of the U.S. Department of Energy's (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project, ground water samples are collected to assess the extent and amount of waterborne contamination that might have come from the mill tailings. This sampling sometimes occurs in contaminated areas where ground water quality has been degraded. Ground water sampling activities may result in field-generated wastes that must be disposed of in a manner protective of human health and the environment.

During ground water sampling, appropriate measures must be taken to dispose of pre-sampling purge water and well development water that is pumped to flush out any newly constructed wells. Additionally, pumping tests may produce thousands of gallons of potentially contaminated ground water that must be properly managed. In addition to the liquid wastes, there is the potential for bringing contaminated soils to the ground surface during the drilling and installation of water wells in areas where the subsurface soils may be contaminated. These soils must be properly managed as well.

This paper addresses the general technical approach that the UMTRA Project will follow in managing field-generated wastes from well drilling, development, sampling, and testing. It will provide guidance for the preparation of Technical Assistance Contractor (TAC) Standard Operating Procedures (SOP) for the management and disposal of field-generated wastes from ground water monitoring and remediation activities.

2.0 BACKGROUND INFORMATION

2.1 WASTE SOURCES AND INFORMATION AVAILABLE ON WASTES

For the most part, the liquid wastes to be handled have been characterized through previous samples and analytical tests. The purge water from existing monitor wells is well characterized for both quality and volume generated during sampling events. The wastes generated from new well installation may be known or unknown depending on the location of the new well.

The nature of drill cuttings and drilling muds (solid wastes) will have a higher degree of uncertainty if a new well is located in the former tailings pile area or in the ground water plume down-gradient of the tailings site. Well development water characteristics from new wells will generally be easier to predict than the solid wastes generated from new wells because of previous characterization of ground water and knowledge of the extent of the contaminant plume.

2.2 CURRENT WASTE DISPOSAL PRACTICES AT UN-REMEDIATED SITES

Current practices of direct disposal/dispersal of waste on-site were implemented before any of the sites had the tailings piles removed or stabilized in place. The practice of disposing of the wastes at the well site was reasonable and acceptable because the generated wastes were no worse than the soils or tailings already at the site. This is in accord with the U.S. Environmental Protection Agency's (EPA) guidance for Superfund sites (EPA, 1991).

With completion of the surface remediation activities, we need to ensure that disposal of the wastes from ground water characterization, monitoring, and remediation activities will not result in dispersing unsafe levels of contaminants onto uncontaminated soil or creating a public/environmental point-of-exposure to the contaminants.

2.3 CURRENT PROJECT GUIDANCE FOR DISPOSAL OF FIELD-GENERATED WASTES

TAC SOP Number 16.1.22, "Controlled Disposal of Potentially Contaminated Materials," was developed to provide guidance for the management of field-generated wastes and is used by the TAC field personnel. However, this procedure lacks specific criteria for determining when disposal of the wastes is acceptable at the site and the specific rationale and documentation for the disposition of the wastes.

Because of this lack of specific guidance on how to determine acceptability, the Project has been using an ad hoc evaluation method to decide each new question that arises for site activities. With increasing levels of ground water program activities each year, more formal, specific guidance is necessary. The guidance developed in this paper will be used to update SOP 16.1.22 or other SOPs as appropriate.

3.0 REGULATORY REQUIREMENTS FOR MANAGEMENT AND DISPOSAL OF GROUND WATER INVESTIGATION-DERIVED WASTES

Disposition of waste materials generated from ground water investigations and remediation at UMTRA sites must be accomplished in accordance with all applicable federal, state, local, and tribal requirements. To determine the applicable regulations, it is first necessary to properly classify these ground water investigation-derived wastes. Currently, there are no specific regulations for classifying UMTRA ground water investigation-derived wastes, thereby making it difficult to determine which regulations or guidelines are germane. The EPA has prepared guidance on the management of investigation-derived wastes from the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) field investigations (EPA, 1991) and on the use of irrigation water (EPA, 1972) that may be relevant to UMTRA ground water investigation-derived wastes.

3.1 URANIUM MILL TAILINGS RADIATION CONTROL ACT (UMTRCA) AND THE ATOMIC ENERGY ACT (AEA)

The Uranium Mill Tailings Radiation Control Act (UMTRCA) and 40 Code of Federal Regulations (CFR) Part 192 (1993) define residual radioactive material (RRM) as (1) radioactive waste in the form of tailings resulting from the processing of ores for the extraction of uranium and other valuable constituents of the ores, and (2) other wastes, determined by DOE to be radioactive, at a processing site which relate to such processing, including any residual stock of unprocessed ores or lowgrade materials. The UMTRA Project considers ground water investigation-derived wastes from processing sites to be potentially RRM under part 2 of this definition, because the ground water investigation-derived wastes may be contaminated with tailings-derived constituents of concern. Ground water investigation-derived wastes classified as RRM should be managed in accordance with 40 CFR Part 192 (1993) Subparts A-C.

If there is no UMTRA site available to accept RRM-classified ground water investigation-derived wastes, these wastes may be collocated under the Atomic Energy Act (AEA), Section 11.e(2), Byproduct Material, which is managed in accordance with 40 CFR Part 192 (1993) Subpart D, with Nuclear Regulatory Commission (NRC) approval. The UMTRA Project has used this option in the past by sending RRM to the Gas Hills UMTRCA Title II site. Another option might be to send the radioactive ground water investigation-derived wastes to a low-level waste disposal site licensed under 10 CFR Part 61 (1993) or applicable state regulations. This option, which has not been pursued before, would require the approval of the licensing agency (NRC or state). The UMTRA Project would also have to demonstrate that the ground water investigation-derived wastes met the site waste acceptance criteria.

3.2 RESOURCE CONSERVATION AND RECOVERY ACT (RCRA)

Ground water investigation-derived waste that is not classified as RRM meets the Resource Conservation and Recovery Act (RCRA) definition for solid waste

in 40 CFR Part 261 (1993). Therefore, a RCRA hazardous waste determination must be made in accordance with 40 CFR Part 262 (1993). Previous characterization of ground water contamination in the vicinity of the source of the ground water investigation-derived wastes could be used to demonstrate reasonable knowledge of the waste characteristics. Costly analytical testing can be avoided in most cases. Ground water investigation-derived wastes determined to be characteristic hazardous waste need to be managed and disposed of in accordance with the EPA's RCRA regulations or the state equivalent. RCRA-regulated ground water investigation-derived wastes may not be placed on UMTRA tailings piles or in UMTRA disposal cells, because these are not RCRA-permitted facilities.

Examination of tailings and ground water analysis data collected to date indicates that there are no ground water investigation-derived wastes produced that meet the RCRA criteria for characteristic hazardous waste. Furthermore, none is expected in the future for purge water, development water, drill cuttings, drilling muds, or sampling equipment. However, if treatment of large quantities of water from aquifer pumping tests is required in the future, it is possible that a hazardous waste may be produced if heavy metals extracted and concentrated in treatment residues exceed toxicity characteristic limits. Analytical testing might be required to make the hazardous waste determination for ground water investigation-derived wastes treatment residues if RCRA hazardous constituents are involved.

Some nonradioactive, nonhazardous ground water investigation-derived wastes may be subject to management requirements under Subtitle D of RCRA as solid wastes. RCRA Subtitle D regulates the disposal of solid waste in facilities such as municipal landfills and is primarily implemented by state regulations. Therefore, some ground water investigation-derived wastes such as personal protective equipment, disposable sampling equipment, and solid waste generated from decontamination procedures may need to be disposed of in a Subtitle D facility (depending on state requirements).

3.3 CLEAN WATER ACT (CWA) AND NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)

Disposal of liquid ground water investigation-derived wastes may also be governed under the Clean Water Act (CWA) regulations. The National Pollutant Discharge Elimination System (NPDES) regulations, 40 CFR Part 122 (1993), require permits, issued by the EPA or authorized states, for point source discharges of pollutants to waters of the U.S. There are no *de minimus* quantity limits, and states have expanded the regulations to cover all discharges to either surface water or ground water or to the ground itself. States and tribes have the authority to establish water quality standards for waters under their jurisdiction. The EPA also requires that an antidegradation policy be part of water quality programs. These standards will usually govern NPDES permit discharge limits.

Since most of these ground water investigation-derived wastes will be classified as nonradioactive and nonhazardous wastes, there are few federal release limits that directly govern their discharge. Therefore, the need to meet state/tribal-imposed requirements for on-site discharge of liquid ground water investigation-derived wastes may be the regulatory issue of most concern. Many of these requirements are administratively set rather than regulatory in nature. As a result, most restrictions on constituent concentrations are imposed in permits and will be state- or site-specific. However, the NPDES regulations have been interpreted such that discharges of intake waters being returned to their source body of water without the addition of pollutants are not regulated.

3.4 COMPLIANCE WITH STATE WATER AND WASTEWATER DISPOSAL REGULATIONS

Because the regulation of solids and wastewater disposal is a function of the state rather than federal preemption, each of the sites at which monitor and other wells are installed, tested, or cleaned out must be in compliance with the appropriate state's law.

The technical requirements of each state's law can probably be complied with by establishing some minimum management standard for the purge wastewater generated and the drill cuttings produced. However, where permitting or notification is required to dispose of the material, the appropriate notice will need to be a part of the ground water program protocol. A summary of the various UMTRA state programs with regard to disposal requirements and the permitting details is included in Table 3.1.

It is suggested that a package of expected level data on the concentrations of all well purge water contaminants and risk assessment information be developed for the monitoring and disposal process. There is a distinct advantage to using site-wide data unless some parameters are going to be well above the regulated limit for that constituent. That package could be submitted to all the states that do not appear to require permits (New Mexico [notification only], Oregon [limited], Utah [permit by rule]). Wyoming and Colorado require permit applications to accompany the package.

The ground water investigation-derived wastes from monitor well activities on tribal lands are not specifically regulated at any of the UMTRA sites. The tribes have general environmental regulations that prohibit pollution of the environment, but do not define those terms as might be found in the RCRA, the CERCLA, or the Toxic Substances Control Act (TSCA). The general prohibitions would obviously cover the discharge of either drilling solids or purge water that exceeded state or federal ground water standards.

This issue may be dealt with at the time the Remedial Action Contractor (RAC) or the TAC applies for monitor well drilling permits. Specifically, the Navajo Nation drilling permit process would permit discussion and permission for future discharges as might be needed by project activities. No other known

Table 3.1 Summary of UMTRA state provisions applicable to purge water and drill cuttings disposal

State/Tribe	Regulatory Provisions	Applicable elements
Colorado	CWQCA §25-8-506	<ol style="list-style-type: none"> 1. Permit issued if showing of "no significant pollution . . . or . . . limited to waters in a specific limited area from which there is no significant migration. 2. 180-day advance permit application required. 3. UMTRA exemption in §25-8-506(3) requires no permit for UMTRCA discharges. 4. New low-level contaminant discharge regulations, effective December 1, 1993.
New Mexico	NMWQA §74-6-5	<ol style="list-style-type: none"> 1. Water Quality Control Commission may require plan for discharge of any contaminant. 2. Requires notice of intent to discharge contaminants if quantity "may with reasonable probabilities injure or be detrimental to human health, animal or plant life, or. . . ."
Oregon	OPCA §468.065	<ol style="list-style-type: none"> 1. State agency defers to Oregon Energy, Waste Disposal Division for permitting. No detailed regulations in place. 2. Ad hoc permitting.
Utah	UWQA §19-5-107	<ol style="list-style-type: none"> 1. "It is unlawful to discharge a pollutant into water of the state or to cause pollution." Pollution includes radiologic contamination. 2. § R448-6-6.1 allows "permit by rule" if facility conforms to "appropriate standards." 3. On-site disposal preferred; off-site disposal requires cleanup to state water quality standards.
Wyoming	WEQA §35-11-301	<ol style="list-style-type: none"> 1. Discharge cannot alter the "physical, chemical, radiological, biological, or bacteriological properties of any waters of the state." 2. Standard limits discharges that would appear to be "harmful" to plants, animals, and humans. 3. Permit required: extensive formal application with data submission.

Table 3.1 Summary of UMTRA state provisions applicable to purge water and drill cuttings disposal (Concluded)

State/Tribe	Regulatory Provisions	Applicable elements
Hopi		No specific regulations addressing disposal of monitoring well solid waste or purge water. However, general regulations prohibiting pollution could be applied if the soils or waters being discharged onto Hopi land were "contaminated or are pollutants." No specific definitions relating to EPA statutes or regulations are available.
Shoshone/ Arapahoe		No specific regulations exist in either tribal code. Discharge or purge water and soils would be permissible if the discharges/deposit did not exceed "background" levels.
Navajo		No specific regulations address this issue. Navajo Nation requires drilling permits to be issued. At time of drilling permit issue, the purpose/discharge estimates/discharge concentrations could be approved by the Tribe. The drilling permit would be the discharge permit in this instance.

restrictions on ground water investigation-derived wastes were found in discussions with the tribal environmental office staff.

3.5 UMTRA TAC NEEDS FOR MANAGEMENT OF GROUND WATER MONITORING AND CHARACTERIZATION WASTES

Although SOP 16.1.22 is available for use for managing wastes from ground water investigation-derived and monitoring activities, it needs to be expanded to document the reasons for the disposal approach used and address all tribal, state, DOE, and EPA regulations and guidelines. Alternatively, existing SOPs of well drilling and sampling could be modified to address the important features called for in this paper.

Finally, the procedure(s) for purge water disposal from monitor wells must be simple to use and consistent for use from site to site. The procedure(s) should include steps that can be, as much as possible, worked out in advance for each site.

4.0 TECHNICAL APPROACH

4.1 HEALTH RISKS ASSOCIATED WITH MANAGEMENT AND DISPOSAL OF GROUND WATER INVESTIGATION-DERIVED WASTES

The health risks associated with the disposal of ground water investigation-derived wastes stem primarily from ingestion of vegetation that has been contaminated from water or drill cuttings placed on the ground near the wells. Some water constituents, such as iron, nitrate, fluoride, and molybdenum, can produce acute toxic effects in animals and humans if ingested at high enough concentrations. Ground water at some sites contains these constituents at elevated concentrations.

Disposition criteria may be needed where there is not any direct regulatory requirement for control of these ground waters. In following the DOE policy commitment to conduct activities in an environmentally sound and safe manner, to minimize risks to the environment, and to minimize worker and public exposure to radiological and non-radiological hazards, it is necessary to evaluate waste disposal thoroughly from a health risk approach even where specific regulations do not address disposal of otherwise non-hazardous substances.

4.2 GENERAL APPROACH AND ASSUMPTIONS

The general approach is to use information currently available on the waste from previous sampling activities or soil tests to classify the waste and to determine its disposition. It is assumed that monitor well purge water quality and quantity will remain relatively constant. Once the disposition of that water is determined, the subsequent disposition will remain the same unless the water quality changes dramatically. For those wastes that have not been previously characterized but about which enough information is available concerning the area in which they are generated, a field screening procedure will be used to determine whether the waste possibly contains contaminants that will make on-site disposal of the material unsuitable. For those wastes where there is insufficient information to be able to justify the wastes' suitability for on-site disposal, the wastes will be stored on-site in drums or tanks until the results of sample analyses are available for determination of the appropriate waste disposal option.

Unless the affected state or tribe has specific restrictions prohibiting the disposal of the waste, the waste exceeds EPA characteristic waste limits, or the waste exceeds DOE cleanup requirements for radionuclides, on-site disposal will be the preferred disposal method. On-site disposal will be justified by a risk-based assessment or demonstration that unrestricted release criteria have been met.

4.3 WASTE DISPOSITION

4.3.1 Liquid waste characterization

Purge water quality is well known from past sampling events. Based on the contaminants and the concentrations of the contaminants, it is possible to determine if the water can be discharged directly on the site where generated.

Surface disposal of ground water purged from wells during sampling activities can be evaluated from the standpoint of the potential for the purge water to represent a risk to human health or the environment.

Direct exposure pathways of purged ground water, such as incidental ingestion or dermal contact, will be prevented by modifying existing SOPs to include steps to prevent the purge water from ponding on the ground surface. If necessary, the purge water will be applied to the ground surface using a low-rate sprayfield system. By eliminating ponding, humans, livestock, and wildlife will not be directly exposed to contaminated ground water.

However, the potential exists for the purge water to be applied on areas covered with vegetation. To evaluate the potential for the purge water to adversely affect plants, the ground water concentrations for each constituent were compared to available federal irrigation water guidelines. These guidelines are not standards or criteria, but are suggested maximum yearly concentrations for irrigation water used up to 20 years on fine textured soils of pH 6.0 to 8.5 (EPA, 1972). These irrigation water guidelines were developed using an agricultural irrigation water application rate of 3 acre feet per acre per year (36 inches of water applied per year). This application rate is significantly higher than the application rate associated with monitor well purging. Based on previous purge water measurements, the average volume pumped from a monitor well is approximately 30 gallons per sampling event. Thus, the irrigation water guidelines are conservative and should provide an adequate margin of safety, assuming the site-specific vegetation has similar sensitivities as agricultural crops.

If the ground water concentration for each of the constituents is below the respective irrigation water guideline, then the potential for purge water disposal to result in adverse effects to plants is considered low. However, if the ground water concentration for one or more of the constituents exceeds the guideline, a more extensive evaluation will be conducted. This evaluation will include a more focused analysis of the ground water data to determine if the maximum concentration for the constituent is representative of conditions throughout the site or whether it is isolated in areal extent.

In order to understand the viability of this approach, the 10 UMTRA sites where surface remediation has been completed were evaluated using the above purge water loading criteria. The potential exists for ground water constituents to build up in the soil from repeated purge water applications and possibly

accumulate to levels that are hazardous to plants, animals, and/or humans. Therefore, the concentration of each constituent in soil, resulting from the application of purge water, was calculated. The soil concentrations presented for each constituent in Tables 4.1 through 4.10 were estimated using a soil accumulation algorithm developed by Oak Ridge National Laboratory and represent the estimated soil concentration resulting from 40 applications (20 years times 2 applications per year) of purge water. This algorithm is conservative in that it assumes no loss from the soil due to leaching or dilution associated with percolating precipitation. The assumptions used to estimate the soil concentrations included a volume of 30 gallons per sampling event, a soil area of 36 square feet (6 feet x 6 feet) covered with purge water (this is a 0.11 acre-foot per acre application rate), a soil depth of water penetration of 6 inches, a soil volume of 0.51 cubic meters, and two soil densities (1.4 grams per cubic centimeter [g/cm^3] for sandy soils and 2.1 g/cm^3 for clayey soils) that span the range of soil conditions at all of the UMTRA sites. The number of purge water applications, 40, was chosen because the anticipated length of time that well purging will occur is 20 years, with 2 purge water applications per year. The application rate of 0.11 acre-foot per acre application is approximately 1/30 the EPA's agricultural irrigation application rate.

To evaluate the estimated soil concentrations, Tables 4.1 through 4.10 include soil concentrations that have been reported to cause toxic effects in agricultural plants (Kabata-Pendias and Pendias, 1992) as well as human health-based soil concentrations (EPA, 1993). The soil concentrations reported to be toxic to plants are concentrations that, if not exceeded, should be protective of most plants. However, they are not based on studies of sensitive or resistant plants and, therefore, cannot be considered protective of all plant types. The human health-based concentrations presented in the tables are based on the assumption that an individual is exposed to a constituent in the soil (via incidental ingestion of 200 mg of soil per day) in a residential setting. While most of the UMTRA sites are in remote geographical locations and the potential for future residential development of the site is probably low, some of the sites are adjacent to areas that are presently zoned for residential uses.

In Tables 4.1 through 4.10, if the ground water concentration is blank for a particular constituent, the constituent has not been detected or it has not been analyzed for during the last two years (1991-1993). A blank entry in the other columns (i.e., irrigation water value, soil concentration protective of plants, and human health-based soil concentration) indicates that no regulatory guidelines or toxicological information was found in the available literature. The concentrations in Tables 4.1 through 4.10 are the highest concentrations found for any well at that site.

In summary, the potential for purge water to represent a hazard to plants or humans can be determined by comparing the ground water concentrations for a particular constituent to the irrigation water value protective of plants and by comparing the estimated soil concentrations to the soil concentrations

Table 4.1 Canonsburg purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Aluminum		20			58,000 ^d	230,000
Arsenic		2			20-30	0.36
Boron		2			25-30	7,000
Barium					580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	350		2,300	1,500	18,000 ^d	
Cadmium		0.05			3-8	39
Chloride	238		1,600	1,000		
Cyanide	0.01		0.07	0.04		1,600
Cobalt		5			25-50	
Chromium		1			75-100	390
Copper		5			60-100	2,900
Fluoride		15			200	4,700
Iron	11	20	72	48	21,000 ^d	
Mercury					0.3-5	23
Potassium	6.3		41	27	18,000	
Magnesium	73		480	320	7,400 ^d	
Manganese	18	10	120	78	1,500-3,000	390

Table 4.1 Canonsburg purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Molybdenum	0.03	0.05	0.20	0.13	2-10	390
Sodium	545		3,600	2,400	9,700 ^d	
Silver						390
Ammonium	1.1		7.2	4.8		
Nickel		2			100	1,600
Nitrate	0.84		5.5	3.7		130,000
Lead		10			100-200	
Phosphate						
Sulfate	1,510		9,800	6,600		
Sulfide						
Antimony					5-10	31
Selenium	0.002	0.02 (0.25) ^e	0.013	0.0087	5-10	390
Silica					300,000 ^d	
Tin					50	47,000
Strontium					200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.465		3	2	4 ^g	230
Vanadium		1			50-150	550
Zinc		10			70-400	23,000

Table 4.1 Canonsburg purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	0.4 pCi/L	5 pCi/L	0.0026 pCi/g	0.0017 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^b	
Thorium-230		60 pCi/L			9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.2 Durango purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based oil concentration (mg/kg) ^c
Aluminum		20			58,000 ^d	230,000
Arsenic		2			20-30	0.36
Boron		2			25-30	7,000
Barium	0.04		0.26	0.17	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	498		3,200	2,200	18,000 ^d	
Cadmium	0.07	0.05	0.46	0.30	3-8	39
Chloride	2,400		16,000	10,000		
Cyanide						1,600
Cobalt		5			25-50	
Chromium		1			75-100	390
Copper	0.01	5	0.065	0.043	60-100	2,900
Fluoride	1.9	15	12	8	200	4,700
Iron	0.56	20	3.7	2.4	21,000 ^d	
Mercury					0.3-5	23
Potassium	41		270	180	18,000 ^d	
Magnesium	690		4,500	2,000	7,400 ^d	
Manganese	5.59	10	36	24	1,500-3,000	390

Table 4.2 Durango purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based oil concentration (mg/kg) ^c
Molybdenum	0.14	0.05	0.91	0.61	2-10	390
Sodium	3,240		21,000	14,000	9,700 ^d	
Silver						390
Ammonium						
Nickel		2			100	1,600
Nitrate	27.9		180	120		130,000
Lead		10			100-200	
Phosphate						
Sulfate	6,820		44,000	30,000		
Sulfide						
Antimony					5-10	31
Selenium	0.16	0.02 (0.25) ^e	1.0	0.69	5-10	390
Silica					300,000 ^d	
Tin					50	47,000
Strontium	10		65	43	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	3.05		20	13	4 ^g	230
Vanadium	0.49	1	3.2	2.1	50-150	550
Zinc	2.69	10	18	12	70-400	23,000

Table 4.2 Durango purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based oil concentration (mg/kg) ^c
Radium-226/228	4.2 pCi/L	5 pCi/L	0.027 pCi/g	0.018 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^b	
Thorium-230		60 pCi/L			9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.3 Grand Junction purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Aluminum	0.31	20	2.0	1.4	58,000 ^d	230,000
Arsenic	0.014	2	0.091	0.061	20-30	0.36
Boron	0.82	2	5.3	3.6	25-30	7,000
Barium	0.63		4.1	2.7	580 ^d	5,500
Beryllium	0.002	0.5	0.013	0.0087	10	0.15
Bromide	7.4		48	32	10-20	
Calcium	775		5,000	3,400	18,000 ^d	
Cadmium	0.001	0.05	0.0065	0.0043	3-8	39
Chloride	2,700		18,000	12,000		
Cyanide	0.01		0.065	0.043		1,600
Cobalt	0.01	5	0.065	0.043	25-50	
Chromium	0.02	1	0.13	0.087	75-100	390
Copper	0.03	5	0.20	0.13	60-100	2,900
Fluoride	1.7	15	11	7.4	200	4,700
Iron	10.3	20	67	45	21,000 ^d	
Mercury					0.3-5	23
Potassium	68		440	300	18,000 ^d	
Magnesium	670		4,400	2,900	7,400 ^d	
Manganese	3.45	10	22	15	1,500-3,000	390

Table 4.3 Grand Junction purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Molybdenum	0.23	0.05	1.5	1.0	2-10	390
Sodium	1,540		10,000	6,700	9,700 ^d	
Silver						390
Ammonium	153		1,000	660		
Nickel	0.04	2	0.26	0.17	100	1,600
Nitrate	35.4		230	150		130,000
Lead	0.002	10	0.013	0.0087	100-200	
Phosphate	0.3		2.0	1.3		
Sulfate	11,000		72,000	48,000		
Sulfide	74		480	320		
Antimony	0.004		0.026	0.017	5-10	31
Selenium	0.17	0.02 (0.25) ^e	1.1	0.74	5-10	390
Silica	21		140	91	300,000 ^d	
Tin					50	47,000
Strontium	7.9		51	34	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.236		1.5	1.0	4 ^g	230
Vanadium	0.11	1	0.72	0.48	50-150	550
Zinc	0.016	10	0.10	0.07	70-400	23,000

Table 4.3 Grand Junction purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	2.3 pCi/L	5 pCi/L	0.014 pCi/g	0.0099 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^b	
Thorium-230	1.7 pCi/L	60 pCi/L	0.011 pCi/g	0.0074 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.4 Green River purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Aluminum	0.26	20	1.7	1.1	58,000 ^d	230,000
Arsenic	0.073	2	0.48	0.32	20-30	0.36
Boron		2			25-30	7,000
Barium					580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	509		3,300	2,200	18,000 ^d	
Cadmium		0.05			3-8	39
Chloride	1,400		9,100	6,100		
Cyanide						1,600
Cobalt		5			25-50	
Chromium	0.01	1	0.065	0.043	75-100	390
Copper		5			60-100	2,900
Fluoride		15			200	4,700
Iron	8.9	20	58	39	21,000 ^d	
Mercury					0.3-5	23
Potassium	24		160	104	18,000 ^d	
Magnesium	427		2,800	1,900	7,400 ^d	
Manganese	1.68	10	11	7.2	1,500-3,000	390

Table 4.4 Green River purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Molybdenum	0.134	0.05	0.87	0.58	2-10	390
Sodium	2,220		14,000	9,600	9,700 ^d	
Silver						390
Ammonium	1.1		7.2	4.8		
Nickel	0.021	2	0.14	0.091	100	1,600
Nitrate	293		1,900	1,300		130,000
Lead	0.065	10	0.42	0.28	100-200	
Phosphate	1.96		13	8.5		
Sulfate	6,540		43,000	28,000		
Sulfide	16.4		110	71		
Antimony					5-10	31
Selenium	0.559	0.02 (0.25) ^e	3.6	2.4	5-10	390
Silica	11.1		72	48	300,000 ^d	
Tin					50	47,000
Strontium					200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.215		1.4	0.93	4 ^g	230
Vanadium	0.092	1	0.6	0.4	50-150	550
Zinc		10			70-400	23,000

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Table 4.4 Green River purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	4.2 pCi/L	5 pCi/L	0.027 pCi/g	0.018 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^h	
Thorium-230		60 pCi/L			9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.5 Lakeview purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Aluminum	0.71	20	4.6	3.1	58,000 ^d	230,000
Arsenic	0.08	2	0.52	0.35	20-30	0.36
Boron	44.4	2	300	190	25-30	7,000
Barium	0.04		0.26	0.17	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide	3.4		22	15	10-20	
Calcium	642		4,200	2,800	18,000 ^d	
Cadmium	0.005	0.05	0.033	0.022	3-8	39
Chloride	2,000		13,000	8,700		
Cyanide	0.11		0.72	0.48		1,600
Cobalt	0.23	5	1.5	1.0	25-50	
Chromium	0.02	1	0.13	0.087	75-100	390
Copper	0.03	5	0.20	0.13	60-100	2,900
Fluoride	7	15	46	30	200	4,700
Iron	11.4	20	74	50	21,000 ^d	
Mercury	0.001		0.0065	0.0043	0.3-5	23
Potassium	26		170	110	18,000 ^d	
Magnesium	245		1,600	1,100	7400 ^d	
Manganese	39	10	250	170	1,500-3,000	390

Table 4.5 Lakeview purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Molybdenum	0.2	0.05	1.3	0.87	2-10	390
Sodium	2,310		15,000	10,000	9,700 ^d	
Silver	0.02		0.13	0.087		390
Ammonium	4.1		27	18		
Nickel	0.13	2	0.85	0.56	100	1,600
Nitrate	5.8		38	25		130,000
Lead	0.003	10			100-200	
Phosphate	1.5		9.8	6.5		
Sulfate	3,730		24,000	16,000		
Sulfide	2.8		18	12		
Antimony	0.006		0.039	0.026	5-10	31
Selenium		0.02 (0.25) ^e			5-10	390
Silica	74		480	320	300,000 ^d	
Tin	0.025		0.16	0.11	50	47,000
Strontium	3.7		24	16	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.012		0.078	0.052	4 ^g	230
Vanadium	0.125	1	0.81	0.54	50-150	550
Zinc	0.398	10	2.6	1.7	70-400	23,000

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Table 4.5 Lakeview purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	1 pCi/L	5 pCi/L	0.0065 pCi/g	0.0043 pCi/g		5 pCi/g
Lead-210	20.3 pCi/L		0.13 pCi/g	0.088 pCi/g		
Polonium-210	7.8 pCi/L		0.051 pCi/g	0.034 pCi/g	0.2-5.9 pCi/g ^h	
Thorium-230	3.5 pCi/L	60 pCi/L	0.023 pCi/g	0.015 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.6 Lowman purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Aluminum	2.46	20	16	11	58,000 ^d	230,000
Arsenic		2			20-30	0.36
Boron	0.07	2	0.46	0.30	25-30	7,000
Barium	1.49		9.7	6.5	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	62.6		410	270	18,000 ^d	
Cadmium		0.05			3-8	39
Chloride	9.6		63	42		
Cyanide						1,600
Cobalt		5			25-50	
Chromium	0.05	1	0.33	0.22	75-100	390
Copper		5			60-100	2900
Fluoride	1.4	15	9.1	6.1	200	4700
Iron	1.92	20	13	8.3	21,000 ^d	
Mercury					0.3-5	23
Potassium	1.9		12	8.3	18,000 ^d	
Magnesium	8.2		53	36	7,400 ^d	
Manganese	0.37	10	2.4	1.6	1,500-3,000	390

Table 4.6 Lowman purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Molybdenum	0.011	0.05	0.072	0.048	2-10	390
Sodium	25		160	110	9,700 ^d	
Silver						390
Ammonium	0.5		3.3	2.2		
Nickel		2			100	1,600
Nitrate	13		85	56		130,000
Lead	0.14	10	0.91	0.61	100-200	
Phosphate	0.2		1.3	0.87		
Sulfate	40		260	170		
Sulfide	2.6		17	11		
Antimony	0.007		0.046	0.030	5-10	31
Selenium		0.02 (0.25) ^e			5-10	390
Silica	40.3		260	180	300,000 ^d	
Tin	0.012		0.078	0.052	50	47,000
Strontium	4.05		26	18	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.07		0.46	0.30	4 ^g	230
Vanadium		1			50-150	550
Zinc	0.036	10	0.23	0.16	70-400	23,000

Table 4.6 Lowman purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	9 pCi/L	5 pCi/L	0.059 pCi/g	0.039 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^b	
Thorium-230		60 pCi/L				9.1 ^d

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.7 Riverton purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Aluminum	79	20	510	340	58,000 ^d	230,000
Arsenic	0.017	2	0.11	0.074	20-30	0.36
Boron		2			25-30	7,000
Barium	2.6		17	11	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide	0.3		2.0	1.3	10-20	
Calcium	605		3,900	2,600	18,000 ^d	
Cadmium	0.006	0.05	0.039	0.026	3-8	39
Chloride	207		1,300	900		
Cyanide	0.03		0.2	0.13		1,600
Cobalt		5			25-50	
Chromium	0.12	1	0.78	0.52	75-100	390
Copper	0.08	5	0.52	0.35	60-100	2,900
Fluoride	2.6	15	17	11	200	4,700
Iron	61	20	400	260	21,000 ^d	
Mercury					0.3-5	23
Potassium	41		270	180	18,000	
Magnesium	291		1,900	1,300	7,400 ^d	

Table 4.7 Riverton purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Manganese	6.4	10	42	28	1,500-3,000	390
Molybdenum	1.27	0.05	8.3	5.5	2-10	390
Sodium	1,360		8,900	5,900	9,700 ^d	
Silver						390
Ammonium	0.95		6.2	4.1		
Nickel	0.28	2	1.8	1.2	100	1,600
Nitrate	46.3		300	200		130,000
Lead	0.244	10	1.6	1.1	100-200	
Phosphate	0.5		3.3	2.2		
Sulfate	4,430		29,000	19,000		
Sulfide	226		1,500	980		
Antimony	0.012		0.078	0.052	5-10	31
Selenium	0.016	0.02 (0.25) ^a	0.1	0.07	5-10	390
Silica	54.9		360	240	300,000 ^d	
Tin	0.102		0.66	0.44	50	47,000
Strontium	3.4		22	15	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	1.97		13	8.6	4 ^g	230
Vanadium	0.18	1	1.2	0.78	50-150	550
Zinc	2.14	10	14	9.3	70-400	23,000

Table 4.7 Riverton purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	12 pCi/L	5 pCi/L	0.078 pCi/g	0.052 pCi/g		5 pCi/g
Lead-210	6.4 pCi/L		0.041 pCi/g	0.028 pCi/g		
Polonium-210	1.4 pCi/L		0.0091 pCi/g	0.0061 pCi/g	0.2-5.9 pCi/g ^b	
Thorium-230	6.7 pCi/L	60 pCi/L	0.044 pCi/g	0.029 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.8 Shiprock purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Aluminum		20			58,000 ^d	230,000
Arsenic	0.03	2	0.2	0.13	20-30	0.36
Boron	1.06	2	6.9	4.6	25-30	7,000
Barium	0.02		0.13	0.087	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	595		3,900	2,600	18,000 ^d	
Cadmium	0.007	0.05	0.046	0.030	3-8	39
Chloride	1,300		8,500	5,700		
Cyanide						1,600
Cobalt	0.027	5	0.18	0.12	25-50	
Chromium	0.05	1	0.33	0.22	75-100	390
Copper		5			60-100	2,900
Fluoride	1.8	15	12	7.8	200	4,700
Iron	10.4	20	68	45	21,000 ^d	
Mercury					0.3-5	23
Potassium	230		1,500	1,000	18,000 ^d	
Magnesium	2,830		18,000	12,000	7,400 ^d	
Manganese	11	10	72	48	1,500-3,000	390

Table 4.8 Shiprock purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Molybdenum	0.06	0.05	0.39	0.26	2-10	390
Sodium	4,300		28,000	19,000	9,700 ^d	
Silver						390
Ammonium	607		4,000	2,600		
Nickel	0.04	2	0.26	0.17	100	1,600
Nitrate	5,300		35,000	23,000		130,000
Lead	0.095	10	0.62	0.41	100-200	
Phosphate	4.2		27	18		
Sulfate	20,800		140,000	90,000		
Sulfide						
Antimony	0.008		0.052	0.035	5-10	31
Selenium	0.664	0.02 (0.25) ^a	4.3	2.9	5-10	390
Silica	15.6		100	68	300,000 ^d	
Tin					50	47,000
Strontium	15.7		100	68	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	2.89		19	13	4 ^g	230
Vanadium	0.39	1	2.5	1.7	50-150	550
Zinc	0.26	10	1.7	1.1	70-400	23,000

Table 4.8 Shiprock purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	6.7 pCi/L	5 pCi/L	0.044 pCi/g	0.029 pCi/g		5 pCi/g
Lead-210	8 pCi/L		0.052 pCi/g	0.035 pCi/g		
Polonium-210	3.9 pCi/L		0.025 pCi/g	0.017 pCi/g	0.2-5.9 pCi/g ^h	
Thorium-230	6.2 pCi/L	60 pCi/L	0.040 pCi/g	0.027 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.9 Salt Lake City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year ^a use (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Aluminum	27.8	20	180	120	58,000 ^d	230,000
Arsenic	0.126	2	0.82	0.55	20-30	0.36
Boron		2			25-30	7,000
Barium	0.471		3.1	2.0	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide					10-20	
Calcium	266		1,700	1,200	18,000 ^d	
Cadmium	0.003	0.05	0.020	0.013	3-8	39
Chloride	2,780		18,000	12,000		
Cyanide						1,600
Cobalt		5			25-50	
Chromium	0.029	1	0.19	0.13	75-100	390
Copper	0.137	5	0.89	0.60	60-100	2,900
Fluoride	2.8	15	18	12	200	4,700
Iron	40.8	20	270	180	21,000 ^d	
Mercury	0.0002		0.0013	0.00087	0.3-5	23
Potassium	237		1,500	1,050	18,000 ^d	
Magnesium	846		5,500	3,700	7,400 ^d	
Manganese	0.918	10	6.0	4.0	1,500-3,000	390

Table 4.9 Salt Lake City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year ^a use (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Molybdenum	0.51	0.05	3.3	2.2	2-10	390
Sodium	3,040		20,000	13,000	9,700 ^d	
Silver	0.041		0.27	0.18		390
Ammonium	20.9		140	91		
Nickel	0.007	2	0.046	0.030	100	1,600
Nitrate	5.5		36	24		130,000
Lead	0.085	10	0.55	0.37	100-200	
Phosphate						
Sulfate	5,520		36,000	24,000		
Sulfide	2.3		15	10		
Antimony	0.027		0.18	0.11	5-10	31
Selenium	0.05	0.02 (0.25) ^e	0.33	0.22	5-10	390
Silica					300,000 ^d	
Tin	0.006		0.039	0.026	50	47,000
Strontium	4.24		28	18	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	0.24		1.6	1.0	4 ^g	230
Vanadium	0.071	1	0.46	0.31	50-150	550
Zinc	0.19	10	1.2	0.83	70-400	23,000

Table 4.9 Salt Lake City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year ^a use (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	2.3 pCi/L	5 pCi/L	0.015 pCi/g	0.0099 pCi/g		5 pCi/g
Lead-210						
Polonium-210					0.2-5.9 pCi/g ^b	
Thorium-230	3.6 pCi/L	60 pCi/L	0.023 pCi/g	0.016 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

Table 4.10 Tuba City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Aluminum	9.7	20	64	42	58,000 ^d	230,000
Arsenic	0.01	2	0.065	0.043	20-30	0.36
Boron	0.14	2	0.91	0.60	25-30	7,000
Barium	0.43		2.8	1.9	580 ^d	5,500
Beryllium		0.5			10	0.15
Bromide	6.2		40	27	10-20	
Calcium	1,071		7,000	4,700	18,000 ^d	
Cadmium	0.002	0.05	0.013	0.008	3-8	39
Chloride	230		1,500	1,000		
Cyanide						1,600
Cobalt		5			25-50	
Chromium	0.038	1	0.25	0.17	75-100	390
Copper		5			60-100	2,900
Fluoride	0.45	15	2.9	2.0	200	4,700
Iron	0.43	20	2.8	1.9	21,000 ^d	
Mercury					0.3-5	23
Potassium	24.5		160	110	18,000 ^d	
Magnesium	628		4,100	2,700	7,400 ^d	
Manganese	0.12	10	0.78	0.52	1,500-3,000	390

Table 4.10 Tuba City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Continued)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health- based soil concentration (mg/kg) ^c
Molybdenum	0.078	0.05	0.51	0.33	2-10	390
Sodium	419		2,700	1,800	9,700 ^d	
Silver						390
Ammonium	150		980	650		
Nickel	0.03	2	0.20	0.13	100	1,600
Nitrate	2,200		14,000	9,600		130,000
Lead	0.08	10	0.52	0.35	100-200	
Phosphate	1.6		10	6.9		
Sulfate	3,700		24,000	16,000		
Sulfide	8.5		55	37		
Antimony					5-10	31
Selenium	0.097	0.02 (0.25) ^e	0.63	0.42	5-10	390
Silica	42		270	180	300,000 ^d	
Tin	0.01		0.065	0.043	50	47,000
Strontium	9.1		59	40	200 ^d	47,000
Thallium					7 ^f	6.3
Uranium	1.01		6.6	4.4	4 ^g	230
Vanadium	0.13	1	0.85	0.56	50-150	550
Zinc	0.286	10	1.9	1.2	70-400	23,000

Table 4.10 Tuba City purge water study - comparison of ground water and soil concentrations to available guidelines for protection of plants and humans (Concluded)

Constituent	Maximum ground water concentration (mg/L)	Irrigation value 20-year use ^a (mg/L)	Estimated soil concentration sandy soils (mg/kg)	Estimated soil concentration clayey soils (mg/kg)	Soil concentration protective of plants (mg/kg) ^b	Human health-based soil concentration (mg/kg) ^c
Radium-226/228	0.8 pCi/L	5 pCi/L	0.0052 pCi/g	0.0035 pCi/g		5 pCi/g
Lead-210	2.5 pCi/L		0.016 pCi/g	0.011 pCi/g		
Polonium-210	5.4 pCi/L		0.035 pCi/g	0.023 pCi/g	0.2-5.9 pCi/g ^h	
Thorium-230	4 pCi/L	60 pCi/L	0.026 pCi/g	0.017 pCi/g	9.1 ^d	

^aFrom USEPA, 1972

^bFrom Kabata-Pendias and Pendias, 1992. These values are not standards or criteria, but are proposed guidelines from several authors.

^cFrom USEPA, Region III, 1992.

^dNot a toxic level or maximum acceptable soil concentration. Value presented is the mean concentration found in naturally occurring surface soils in the western U.S. west of the 96th meridian (USGS, 1984).

^eIn the presence of >500 mg/L sulfate. This is a state of New Mexico water quality standard for "not to be exceeded in irrigation water" (1991).

^fConcentration in soil that was reported to result in injury to many crop plants (USGS, 1980). It should be noted that some sensitive plants, such as tobacco plants, have shown toxic effects at 1 mg/kg thallium in the soil.

^gNot a toxic concentration; value shown is concentration in cultivated soil that resulted in no obvious damage to fruits and vegetables grown in this soil (USGS, 1980).

^hNot a toxic level or maximum acceptable soil concentration. This value or range of values is naturally occurring abundance (Kabata-Pendias and Pendias, 1992) in surface soils.

mg/L = milligrams per liter

mg/kg = milligrams per kilogram

pCi/g = picocuries per gram

pCi/L = picocuries per liter

protective of plants and protective of humans. To use Table 4.1 (Canonsburg site) as an example, the maximum ground water concentration of manganese (18 mg/L) is the only constituent concentration that exceeds the irrigation water value (10 mg/L). This suggests that further evaluation of available manganese data at this site should be conducted prior to application of purge water.

In terms of the potential for soil accumulation, the estimated soil concentration in a particular table can be compared with the lower of the two soil guideline values (i.e., protective of plants or protective of humans) to determine if buildup in the soil would be of concern. At the Canonsburg site, none of the constituents have estimated soil concentrations that would be of concern to agricultural crops or to human health via incidental soil ingestion, even after 40 applications of purge water (Table 4.1).

As with the irrigation water guidelines, if a constituent(s) at a particular site is expected to accumulate to a potentially hazardous level, then a more detailed risk analysis will be conducted. This determination will be completed before the wells are sampled and disposal guidelines for the purge water for each well at each site will be prepared for use by the water samplers. Table 4.11 is a listing of constituents of concern that exceed recommended maximums or are higher than background values from western U.S. soils. The two constituents of concern are arsenic and bromide.

Well pump test water will be evaluated in the same manner for on-site disposal.

4.3.2 Liquid waste disposal

A well water disposal logic flow chart (Figure 4.1) was developed to classify and evaluate liquid field-generated wastes in order to determine their disposition. Currently, many sites have not yet had the tailings stabilized and disposal cells completed. At these sites, any water wastes will be directly disposed of on the ground of the designated processing site that is already contaminated. If the remedial action is under way at a given site, the water wastes will be disposed of on the ground in un-remediated areas of the site, in the disposal cell that is under construction, or in the site's construction waste water pond, as appropriate.

If the surface remediation is complete, greater care must be taken with the waste water disposition. First, the water quality must be known or predictable from previous sampling or field screening (conductivity, pH, and radioactivity) before any action can be taken. With this information, the water quality will be compared to a table consisting of risk-based guideline concentrations that will not produce adverse environmental effects if the water is discharged on the ground periodically for up to 20 years. A 20-year period was selected because the monitoring and cleanup of a site may last up to 20 years. If no adverse effects are identified, the waste water will be disposed of on the ground, assuming that the proposed approach conforms to state and/or tribal regulations. If adverse effects are identified, consideration will be given to

Table 4.11 Maximum levels of constituents of concern in top 6 inches of soil after 40 applications of purge water^a

Site	Arsenic mg/kg	Boron mg/kg	Bromide mg/kg	Molybdenum mg/kg	Uranium mg/kg
Canonsburg	---	---	----	---	---
Durango	---	---	----	---	----
Grand Junction	---	---	----	---	---
Green River	0.48	---	----	---	---
Lakeview	0.52	289	22	---	---
Lowman	---	---	----	---	---
Riverton	----	---	---	8.3	12.8
Shiprock	----	---	---	---	18.8
Salt Lake City	0.82	---	---	3.3	---
Tuba	---	---	40.4	---	6.6

Note: --- Indicates maximum concentrations for site were below recommended guidelines or maximums as shown in Tables 4.1 through 4.10. See Tables 4.1 through 4.10 for specific maximum concentrations of all constituents in soil after 40 purge water applications.

^aThe constituent concentrations in Table 4.11 do not include those constituents that are common non-hazardous soil elements such as calcium, chloride, sodium, or sulfate.

The basis for listing the concentration for the constituents listed above in Table 4.11 and the appropriate footnote for the constituent (from Tables 4.1 through 4.10) are listed below:

Arsenic - 0.36 mg/kg(c)
Boron - 25-30 mg/kg(b)
Bromide - 0-20 mg/kg(b)
Molybdenum - 2-10 mg/kg(b)
Uranium - 4 mg/kg(g)

FIGURE 4.1
UMTRA WELL WATER DISPOSAL LOGIC FLOW CHART

storing and subsequently disposing of the waste water at an appropriate facility or else installing low-purge sampling pumps to minimize the volume of water waste generated, which will permit direct on-ground disposal. If large volumes of waste water are anticipated, such as are generated when performing pumping tests at a site, an assessment of on-ground disposal will be performed. This assessment, in conjunction with a review of state discharge regulations, will determine whether the wastes can be disposed of on the ground or will require more extensive treatment or management.

The volume of water produced will vary more than water quality due to the type of activity that produces the water. Purge water volume from monitor wells has been found to be in the range of 10-40 gallons per monitor well. Table 4.12 lists the quantities of purge water for eight different UMTRA sites. These sites were selected as being representative of "typical" UMTRA sites. The purge water volume at the Maybell site is not considered representative, because that site has not yet undergone remediation.

When a new well is installed, the volume of water produced during the well development can be expected to range from 10-200 gallons, generally totaling less than 100 gallons.

Water produced from aquifer pumping tests will more likely be tens of thousands of gallons rather than tens of gallons. The spring, 1993, Green River, Utah, aquifer pumping test produced approximately 16,000 gallons of water, and the proposed Tuba City, Arizona, aquifer pump test may produce something on the order of 150,000 gallons to 250,000 gallons of water. Obviously, disposal of these large volumes of pump test water will require more detailed study than the average twice a year disposal of 30 gallons of purge water from monitor well sampling.

4.3.3 Solid waste characterization and disposal

Figure 4.2 is the logic flow chart for the disposal of well construction solid wastes. Solid wastes produced from field activities consist of drill cuttings and drilling muds from installing new wells. These volumes are generally small and can be placed in drums if needed or spread around the drill site if appropriate. Typical waste quantities for 2-inch to 4-inch monitor wells are 0.1 to 0.2 cubic foot per foot of well drilled, or approximately 1-2 gallons per foot of hole drilled. A 50-foot-deep well, therefore, would produce approximately 1 to 2, 55-gallon drums of waste cuttings.

It is assumed that the easiest and most likely to detect contaminants in solid wastes will be radioactive elements left over from the remedial action after supplemental standards have been applied, or perhaps radionuclides such as uranium that were not specifically analyzed for during the cleanup verification sampling process. A survey was conducted of twelve UMTRA sites where tailings and ground water samples were analyzed for 40 CFR Part 264 (1993), Appendix IX, and 40 CFR Part 192 (1993), Appendix I, hazardous organic

Table 4.12 Typical UMTRA site monitor well purge water volumes

Site	Non-background purge water total volume (Gallons)	Number of non- background wells sampled	Average purge water volume per well (Gallons)
Belfield	295	13	23
Bowman	887	23	38
Durango	463	15	31
Grand Junction	114	11	10
Lakeview	162	8	20
Lowman	20	2	10
Maybell	2632	37	71 ^a
Tuba City	234	6	39

^aMaybell site volumes are larger because these wells were completed in deeper intervals than wells at most other sites.

constituents. This survey showed only one site, New Rifle, Colorado, where sufficiently elevated concentrations were detected to warrant further characterization (UMTRA Document 0.2.2.38.41, "Appendix IX Special Study," November 8, 1989).

Because uranium is typically the only radionuclide detected in water samples (attributable, in part, to its mobility), we would assume that some source term of uranium (natural or man-enhanced levels) within the soil column may still persist if it is detected in a particular water sample. Whatever the case, qualitative radiometric screening tests will be performed to confirm the presence or absence of radionuclides in the drill cuttings. If the site has not yet undergone surface remediation, the solid wastes will be disposed of directly on the tailings pile without screening.

It has been demonstrated on the Weldon Springs Site Remedial Action Project that a 2-inch by 2-inch sodium iodide detector is capable of reliably detecting 10 picocuries per gram (pCi/g) of uranium-238 in soil, while a geiger counter can detect about 15 pCi/g. The sodium iodide detector easily detects much less than 5 pCi/g of radium-226 in soil. Therefore, the TAC proposes to expand SOP 16.1.22 and/or well-drilling SOPs to include a radiometric screening process for drill cuttings to determine whether or not they can be safely disposed of on the site, or whether more accurate quantitative analytical characterization must be obtained before the decision regarding their disposition is made.

First, the surface of the drill cuttings will be scanned with a geiger counter to determine if there is any gross indication of radioactivity. This indication will be noted and taken into consideration when making disposition decisions following the next step. Second, the drill cuttings will be placed into a 5-gallon container, around a central tube, approximately 3 inches in diameter. A 2-inch by 2-inch sodium iodide detector will be placed into this tube and a timed count rate will be taken. If the result is less than background plus 3 standard deviations ($\text{background} + 3\sqrt{\text{background}}$) and the geiger counter measurement is less than twice background, the cuttings will be disposed of on the site. (Note: The theoretical standard deviation of a measurement is the square root of the total counts observed. Background plus 3 standard deviations will be a positive indication of elevated radioactivity that should receive more in-depth evaluation.)

If the result exceeds the background count rate plus 3 standard deviations or the geiger counter measurement is greater than twice background, the 2-inch by 2-inch sodium iodide results will be compared to tables indicating the expected count rates for 30 pCi/g of uranium-238, the unrestricted release limit for this radionuclide found in DOE Order 5400.5. If it exceeds this value, the cuttings will be drummed and stored until samples can be sent to a laboratory for more accurate quantitative characterization. If the radionuclides present are determined to be below established limits for unrestricted disposal, they will then be discarded on the site. Otherwise, they will be permanently disposed of at another open UMTRA site or a facility that is designed to accept such wastes. It should be noted that assuming uranium-238 as the radionuclide of

concern is conservative, since if radium-226 were present, the count rate from 5 pCi/g of radium-226 would exceed the count rate of 30 pCi/g of uranium-238.

Residues from any water treatment activities will be managed slightly differently. All residue will be subject to both radiometric and chemical characterization. If it is determined to be non-RCRA and falls below unrestricted release limits for radionuclides, it will be disposed of on-site or in a local landfill. Otherwise, it will be disposed of at an appropriate facility.

5.0 SUMMARY AND RECOMMENDATIONS

This discussion provides a sound technical basis regarding the technical and regulatory compliance approach for the management of UMTRA ground water investigation-derived wastes. It provides defensible, practical, and reasonable approaches for dealing with both solid and liquid wastes generated during the course of well drilling, well sampling, and well testing. The logic flows for dealing with liquid and solid wastes can be found in Figures 4.1 and 4.2, respectively. Generally, the preferred solution will be to dispose of the wastes on-site, whenever it can be justified on the basis of projected risk to humans or the environment. When that is not the case, the wastes will be stored until adequate characterization analyses can be obtained, and appropriate actions will be taken based on those results.

The TAC recommends that SOP 16.1.22, or other SOPs dealing with well drilling and water sampling, be revised to reflect the more rigorous approach outlined in this paper.

6.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this document.

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- 40 CFR Part 261 (1993), "Identification and Listing of Hazardous Waste," Title 40, *Code of Federal Regulations*, Part 261, U.S. Environmental Protection Agency, Office of the Federal Register, National Archives and Records Administration, Washington, D.C.
- 40 CFR Part 262 (1993), "Standards Applicable to Generators of Hazardous Waste," Title 40, *Code of Federal Regulations*, Part 262, U.S. Environmental Protection Agency, Office of the Federal Register, National Archives and Records Administration, Washington, D.C.

DOE ORDERS

- 5400.5, *Radiation Protection of the Public and the Environment*, June 5, 1990, U.S. Department of Energy, Washington D.C.

STATE CODES

CWQCA, "Colorado Water Quality Control Act," Colorado Revised Statutes, §25-8-101 *et seq.*

NMWQA, "Water Quality Act," New Mexico Statutes Annotated, §74-6-1 *et seq.*

OPCA, "Oregon Pollution Control Act," Oregon Revised Statutes, §468.005 *et seq.*

UWQA, "Water Quality Act," Utah Code Annotated, §19-5-101 *et seq.*

WEQA, "Wyoming Environmental Quality Act," Wyoming Statutes, §35-11-101 *et seq.*

U.S. CODE

AEA, "Atomic Energy Act," Title 42, *United States Code*, § 2011 *et seq.*

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