UMTRA PROJECT WATER SAMPLING AND ANALYSIS PLAN

SALT LAKE CITY, UTAH

RECEIVED
JUL 28 1995
OSTI

June 1995

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

TJ

INTENDED FOR PUBLIC RELEASE

This report has been reproduced from the best available copy. Available in paper copy and microfiche

Number of pages in this report: 60

DOE and DOE contractors can obtain copies of this report from:

**Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831
(615) 576-8401**

This report is publicly available from:

**National Technical Information Service
Department of Commerce
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4650**

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

**UMTRA PROJECT
WATER SAMPLING AND ANALYSIS PLAN
SALT LAKE CITY, UTAH**

June 1995

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

**Prepared by
Jacobs Engineering Group Inc.
Albuquerque, New Mexico**

TABLE OF CONTENTS

<u>Section</u>	<u>Page</u>
1.0 INTRODUCTION.....	1-1
1.1 Purpose.....	1-1
1.2 Site location	1-1
1.3 Site history.....	1-1
1.4 Site status.....	1-6
1.5 Sampling plan summary.....	1-7
2.0 SITE CONDITIONS	2-1
2.1 Site background information.....	2-1
2.1.1 Surrounding land uses	2-1
2.1.2 Surrounding water use.....	2-3
2.1.3 Contaminant sources.....	2-4
2.2 Geology and hydrology	2-5
2.2.1 Physical setting.....	2-5
2.2.2 Geology	2-5
2.2.3 Ground water hydrology.....	2-5
2.2.4 Surface water hydrology.....	2-11
2.3 Water quality.....	2-12
2.3.1 Background water quality.....	2-12
2.3.2 Ground water contaminant delineation	2-19
2.3.3 Surface water and sediment sampling	2-21
2.4 Site conceptual model	2-23
3.0 DATA COLLECTION OBJECTIVES.....	3-1
3.1 Regulatory requirements	3-1
3.2 Compliance monitoring	3-1
3.3 Site characterization.....	3-1
4.0 DATA QUALITY REQUIREMENTS.....	4-1
5.0 SAMPLING PLAN	5-1
5.1 Sampling locations	5-1
5.2 Analyte selection	5-4
5.3 Sampling frequency.....	5-4
5.4 Data evaluation methods	5-7
5.5 Response to anomalous data	5-7
6.0 LIST OF CONTRIBUTORS.....	6-1
7.0 REFERENCES	7-1

LIST OF FIGURES

Figure	Page
1.1 Location of the South Clive Disposal Site and the Salt Lake City Vitro processing site near Salt Lake City, Utah	1-2
1.2 Location of the Salt Lake City, Utah, Vitro processing site	1-3
1.3 Monitor well, surface water, sediment, and borehole sampling locations, Salt Lake City, Utah, Vitro processing site	1-4
2.1 Land use and locations of water wells, Salt Lake City, Utah, site	2-2
2.2 Geologic cross section, monitor well, and borehole locations, Salt Lake City, Utah, Vitro processing site	2-6
2.3 Geologic cross section D-D', Salt Lake City, Utah, site	2-7
2.4 Ground water table contours of the unconfined aquifer, Salt Lake City, Utah, Vitro processing site	2-9
2.5 Approximate extent of sulfate contamination (1992-1993 data), Salt Lake City, Utah, Vitro processing site	2-20

LIST OF TABLES

<u>Table</u>	<u>Page</u>
1.1 Monitor wells used to determine water quality in the unconfined and confined aquifers.....	1-8
1.2 Proposed sampling locations and analytical parameters	1-9
2.1 Water quality of the confined aquifer, Salt Lake City, Utah, site	2-13
2.2 Ground water quality data, city of South Salt Lake proposed municipal water supply well, Salt Lake City, Utah, site	2-15
2.3 Comparison of background and site-related contaminated filtered ground water quality in the unconfined aquifer at Salt Lake City, Utah, 1990-1995	2-18
2.4 Summary of Mill Creek surface water quality data, December 1994, Salt Lake City, Utah, site	2-22
2.5 Summary of Vitro Ditch and South Vitro Ditch surface water quality data, December 1994, Salt Lake City, Utah, site	2-24
2.6 Summary of Vitro Ditch and South Vitro Ditch sediment chemistry data, December 1993 and 1994, Salt Lake City, Utah, site	2-25
5.1 Order for sampling and summary of ground water monitor wells to be sampled, Salt Lake City, Utah, site.....	5-2
5.2 Order of sampling and summary of surface water locations to be sampled, Salt Lake City, Utah, site	5-3
5.3 Summary of sediment locations to be sampled, Salt Lake City, Utah, site	5-5
5.4 Summary of field parameters and laboratory analytes to be measured in ground water, surface water, and sediment, Salt Lake City, Utah, site.....	5-6

LIST OF ACRONYMS

<u>Acronym</u>	<u>Definition</u>
AEC	U.S. Atomic Energy Commission
CVWRF	Central Valley Water Reclamation Facility
DDPA	monododecyl phosphoric acid
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
LTSP	long-term surveillance plan
NRC	U.S. Nuclear Regulatory Commission
RAC	remedial action contractor
SOP	standard operating procedures
SOWP	site observational work plan
TAD	Technical Approach Document
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
WSAP	water sampling and analysis plan

1.0 INTRODUCTION

1.1 PURPOSE

This water sampling and analysis plan (WSAP) describes planned, routine ground water sampling activities at the U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project site in Salt Lake City, Utah. The plan identifies and justifies sampling locations, analytical parameters, detection limits, and sampling frequencies for routine monitoring stations at the site. The ground water data are used for site characterization and risk assessment.

The regulatory basis for routine ground water monitoring at UMTRA Project sites is derived from the U.S. Environmental Protection Agency (EPA) regulations in 40 CFR Part 192 (1994) and the proposed EPA standards of 1995 (60 FR 2854). Sampling procedures are guided by the UMTRA Project standard operating procedures (SOP) (JEG, n.d.), the *Technical Approach Document* (TAD) (DOE, 1989), and the most effective technical approach for the site.

1.2 SITE LOCATION

The Salt Lake City Vitro processing site is 4 miles (mi) (6 kilometers [km]) south-southwest of the center of Salt Lake City, Salt Lake County, Utah, in Sections 25 and 26, Range 1 West and Township 1 South (Figure 1.1). The site comprises 128 acres (ac) (52 hectares [ha]) at the northeastern corner of the intersection of 3300 South Street and 900 West Street (Figure 1.2). The Central Valley Water Reclamation Facility (CVWRF) sewage treatment plant is located on adjacent property north of the central portion of the site. The CVWRF board (Figure 1.3) now owns the Salt Lake City Vitro processing site, except for a 25 by 25-foot (ft) (8 by 8-meter [m]) strip of land surrounding the municipal water supply well and an easement owned by the city of South Salt Lake.

Between 1985 and 1987, a total of 2,798,000 cubic yards (yd³) (2,139,000 cubic meters [m³]) of tailings were removed from the Salt Lake City Vitro site and stabilized in a disposal cell at Clive, Tooele County, Utah. The Clive site is approximately 85 mi (140 km) west of Salt Lake City (Figure 1.1). No sampling efforts are planned for the Clive site within the next 5 years. Therefore, the Clive site will not be discussed further in this document. The ground water compliance strategy for the Clive site is supplementary standards for the underlying very saline shallow aquifer.

1.3 SITE HISTORY

In 1941, a large smelter known as the Calunite Smelter, Inc., was completed at 3300 South Street and 900 West Street in Salt Lake City. In 1946, the plant became known as the Vitro Chemical Company Calunite Plant. From 1941 through 1951, this smelter processed aluminum from aluminite. In May 1951,

Figure 1.1
Location of the South Clive Disposal Site and the
Salt Lake City Vitro Processing Site
Near Salt Lake City, Utah

Figure 1.2
Location of the Salt Lake City, Utah, Vitro Processing Site

Figure 1.3
Monitor Well, Surface Water, Sediment, and Borehole Sampling Locations
Salt Lake City, Utah, Vitro Processing Site

MAC: SITE/SLC/WSAP/SITELOC&WELLSW

DOE/AL/62350-99
REV. 1, VER. 3

21-Jun-95
003D3WP.DOC (SLC)

the Vitro plant began processing uranium ore under contract with the U.S. Atomic Energy Commission (AEC). Because the Vitro Chemical Company was the plant operator, the site often is referred to as the Vitro processing site.

From 1951 through 1964, the Vitro plant processed uranium ore by acid leaching. In 1965, the mill converted to the production of vanadium. Vanadium production ceased in 1968 and the plant was dismantled in 1970.

In 1951, the Vitro Chemical Company began processing uranium ore using the phosphate precipitation technique. Uranium ore was first roasted and then leached in a sulfuric acid solution. Metallic aluminum was added to the solution as a reducing agent and the pH was kept between 1.0 and 1.8 to promote uranium precipitation (in a reduced trivalent form) as a phosphate. After the solids (tails) were separated from the uranium-bearing leachate, the uranium was precipitated from the acid solution by adding orthophosphate. The uranium phosphate precipitate then was digested in a 10- to 30-percent sodium or potassium hydroxide solution to remove excess phosphate. The mill processed 100 tons (90 tonnes) of ore per day in 1951, expanding to 500 tons (454 tonnes) per day by 1956 (Merritt, 1971).

When the plant converted to a solvent extraction processing circuit in 1957, 600 tons (540 tonnes) of ore per day were processed. After the ore was roasted and leached in a sulfuric acid solution adjusted to a pH of 1, a reducing agent (typically sodium hydrosulfide) was added to the slurry to reduce ferric iron and molybdenum. The solids were separated from the solution, the solids were disposed of in tailings piles, and the solution was mixed with an organic solution. This organic solution was 10 percent or less monododecyl phosphoric acid (DDPA) dissolved in kerosene. While kerosene solution and acid-aqueous solution were immiscible, intensive agitation allowed the uranium in the acid solution to complex with the DDPA in the kerosene solution, thus removing the uranium from the acid solution. The spent acid solution, called raffinate, was pumped to evaporation ponds. This raffinate may have contained up to 5 parts per million DDPA (Merritt, 1971).

The uranium was extracted from the kerosene solution by mixing the organic liquid with aqueous 10 normal hydrochloric acid; the uranium complexed with chloride in the aqueous solution, which then was separated from the immiscible kerosene. The hydrochloric acid solution was evaporated, with the distilled acid recovered for reuse. After uranium-bearing solids left by evaporation of the acid were diluted with water, ammonia was added to precipitate ammonium diuranate, which was heated to drive off excess ammonia. This process resulted in a final product of uranium oxide (U_3O_8).

The DDPA-kerosene solution was recycled. However, buildup of thorium, titanium, and scandium in the solvent required periodic treatment to remove these elements from the kerosene solution. Stripping with 10 percent hydrofluoric acid solution resulted in precipitation of thorium, titanium, and

scandium as fluorides. These precipitates were shipped elsewhere for refining (Merritt, 1971).

Remedial action under the UMTRA Surface Project at the Salt Lake City Vitro processing site occurred from 1985 to 1987. A total of 2,798,000 yd³ (2,139,000 m³) of tailings were removed from the site and stabilized in a disposal cell at Clive, Utah. The state of Utah was the remedial action contractor (RAC). The state was responsible for removing the tailings and for submitting a site completion and certification report to the DOE for U.S. Nuclear Regulatory Commission (NRC) concurrence, certifying that the surface is free of contamination.

1.4 SITE STATUS

Following is a status list of major documents associated with the Salt Lake City Vitro site:

- Vitro Certification Report: The NRC is reviewing the preliminary final document containing state of Utah and DOE responses to NRC comments on the draft document.
- Clive Completion Report: The UMTRA RAC prepared the draft document at the DOE's request. The state of Utah is reviewing the document prior to submittal to the NRC.
- Long-term Surveillance Plan (LTSP): The draft LTSP is scheduled to be completed in August 1995.
- Baseline Risk Assessment: The DOE has reviewed the draft Baseline Risk Assessment, and the technical assistance contractor is responding to DOE comments.
- Site Observational Work Plan (SOWP): The SOWP is scheduled to start in 1999.
- Golf Course Report: This report, to be issued June 1995, discusses potential impacts to the existing ground water contamination as a result of the proposed golf course expansion and associated irrigation.
- Water Level Monitoring Report: This report, to be issued in June 1995, discusses the results of 1 year of water level monitoring at the Salt Lake City site to determine what impacts, if any, resulted from golf course driving range irrigation.

1.5 SAMPLING PLAN SUMMARY

The current sampling plan for the Salt Lake City Vitro site is to collect ground water, surface water, and sediment samples biannually from selected DOE monitor wells, two CVWRF dewatering wells, the South Vitro Ditch, the Vitro Ditch, and Mill Creek for the next 2 years. Figure 1.3 presents locations of all site monitor wells, existing surface water sampling points, and sediment sampling points. Table 1.1 presents monitor well completion data for both the unconfined and confined aquifer wells. Table 1.2 lists all proposed sampling locations and constituents to be analyzed over the next 2 years.

Ground water analytes selected for analysis include major elements and field parameters as indicators of general water quality and constituents identified as site-related contaminants in ground water per the draft *Baseline Risk Assessment of Ground Water Contamination at the Uranium Mill Tailings Site, Salt Lake City, Utah* (DOE, 1994). Also, arsenic is analyzed for comparison to ambient concentrations in background ground water. Unfiltered samples will be analyzed for trace metals, which may be adsorbed on suspended particulates.

The surface water analytes selected for analysis primarily monitor the effects of ground water discharge to the South Vitro Ditch. Recent sampling has detected constituents (including uranium, molybdenum, and silver) in the South Vitro Ditch that may be site-related. Other constituents detected in the South Vitro Ditch and the Vitro Ditch, such as lead and copper, may have an ambient origin. Further sampling is required to determine the sources of these constituents.

Sediments in the South Vitro Ditch appear to have adsorbed constituents from surface waters. Those constituents at elevated levels in the South Vitro Ditch include arsenic, copper, lead, molybdenum, and silver. Off-site locations fed by storm sewers need further sampling to determine if these constituents are site-related or due to ambient conditions.

The last sampling event at the site was completed in December 1994. The next scheduled water quality sampling round will occur in July 1995 and will include the sites listed in Table 1.2. It is recommended that the proposed sampling plan be implemented biannually for the next 2 years and annually thereafter, provided the water quality is stable. The end point for routine monitoring will occur when the ground water compliance strategy is accepted.

Table 1.1 Monitor wells used to determine water quality in the unconfined and confined aquifers

Well	Location	Screened interval (depth below land surface)		Year sampled	Number of sampling rounds
		(ft)	(m)		
Unconfined aquifer					
SLC-01-006	Off-site upgradient	26-28	7.9-8.5	83,94	3
SLC-01-007	Off-site crossgradient	26-28	7.9-8.5	83-94	11
SLC-01-008	Off-site downgradient	26-28	7.9-8.5	86-93	9
SLC-01-130	On-site crossgradient	31.8-41.8	9.7-12.7	92-94	4
SLC-01-131	On-site downgradient	34.7-44.7	10.6-13.6	92-94	4
SLC-01-132	On-site crossgradient	36.3-46.3	12.4-14.1	92-94	4
SLC-01-133	On-site crossgradient	35.0-45.0	10.7-13.7	92-94	4
SLC-01-134	On-site crossgradient	32.2-42.2	9.8-12.9	92-94	4
SLC-01-136	On-site crossgradient	25.5-45.5	7.8-13.9	92-94	4
SLC-01-139	On-site downgradient	to be determined		not sampled	0
SLC-01-140	On-site downgradient	to be determined		not sampled	0
Confined aquifer					
SLC-01-001	Off-site south	100-110	30.5-33.5	86-92	6
SLC-01-002	Off-site northeast	119-129	36.3-39.3	86-93	7
SLC-01-003	Off-site north	110-120	33.5-36.6	86-93	7
SLC-01-005	Off-site west	115.5-125.5	35.2-38.3	83-90	3

Note: Wells 139 and 140 are private wells owned by the CVWRF board.

Table 1.2 Proposed sampling locations and analytical parameters

Monitor wells	Parameters
001, 002, 003, 006, 007, 008, 130, 131, 132, 133, 134, 136, 139, and 140	Alkalinity, ammonium, arsenic ^a , barium, calcium, chloride, fluoride, iron ^a , lead, magnesium, manganese, molybdenum ^a , ph, potassium, radium-226, silver ^a , sodium, strontium, sulfate, TDS, uranium ^a , oxidation-reduction potential, dissolved oxygen, turbidity, and temperature.
Surface water	Parameters
180, 182, 186, 187, and seven additional sites not previously sampled - 192, 193, 194, 195, 196, 197, and 198	Filtered - alkalinity, calcium, chloride, sulfate, iron, lead, copper, magnesium, molybdenum, silver, sodium, uranium, vanadium; unfiltered - arsenic, copper, iron, lead, molybdenum, silver, uranium, and vanadium.
Sediment samples	Parameters
Surface water locations 191, 194, 186, 187, 195, 196	Arsenic, copper, lead, molybdenum, silver, and uranium.

^aBoth filtered and unfiltered.

2.0 SITE CONDITIONS

2.1 SITE BACKGROUND INFORMATION

2.1.1 Surrounding land uses

The 128-ac (52-ha) former Vitro processing site is in a primarily urban area in the city of South Salt Lake. As the metropolitan area expanded, land usage around the site changed from agricultural and limited residential use to industrial use.

The CVWRF board owns the entire Salt Lake City Vitro processing site, except for a 25 by 25-ft (8 by 8-m) strip of land surrounding the municipal water supply well and an easement owned by the city of South Salt Lake. A 28-ac (11-ha) portion of the land in the southeastern corner of the site has been leased and developed into a golf driving range. The remaining land is vacant but probably will be developed as an industrial, commercial, or recreational area once the NRC certifies the site. Figure 2.1 shows land use within an approximate 0.5-mi (0.8-km) radius of the site.

The CVWRF sewage treatment plant (on adjacent property north of the central portion of the site) and the channel of Mill Creek are north of the golf course driving range. The CVWRF discharges its effluent directly into Mill Creek near the northwestern corner of the facility (Figure 1.3). Warehouses and Denver & Rio Grande Western Railroad property are still farther north.

The railroad also occupies the land on the east side of the site. This property extends as far east as Interstate 15 and contains a swampy area drained by the Vitro Ditch onto the site. A cement plant is at the southeastern corner of the site. Just southeast of the site is the railroad/3300 South Street underpass which extends 15 to 20 ft (4 to 6 m) below ground level. A lift station pumps storm water and ground water from the infiltration gallery beneath the underpass, discharging the water into a drain line that discharges into the South Vitro Ditch.

On the south, the site is bounded by 3300 South Street. Mainly car dealerships and junk car yards occupy the land across 3300 South Street. A mixed residential and farming area consisting of about 20 to 25 residences is about 300 ft (90 m) away from the site's southwestern corner, across 3300 South Street. These are the nearest residences to the Salt Lake City Vitro site. Some residents keep livestock, and cattle and horses graze on nearby fields.

On the west, the site is bounded by 900 West Street. The Jordan River controls land-use patterns further west. This area includes light industry, commercial developments, and vacant land, with about 10 residences on 1100 West Street. Some of these residents keep ducks, geese, and horses. An

Figure 2.1
Land Use and Locations of Water Wells
Salt Lake City, Utah, Site

MAC: SITE/SLC/WSAP/LANDUSE

DOE/AL/62350-99
REV. 1, VER. 3

21-Jun-95

003D3WP.DOC (SLC)

apartment complex, a correction facility, and a recreation area associated with the Jordan River are the other regional developments.

Large-diameter sewer inlet mains, buried about 20 ft (6 m) below grade, bring sewage from the south and north to the CVWRF. The south main flows north along the west side of 900 West Street, then east to the southwestern corner of the CVWRF. The north main then flows south from a Mill Creek crossing upstream of the railroad, then west to the southeastern portion of the CVWRF.

2.1.2 Surrounding water use

A ground water-well records search and field reconnaissance were conducted in April 1994 at and near the former uranium processing site. Detailed examination of the state engineer's database and intensive field investigation downgradient from the site did not reveal any users of the shallow, unconfined aquifer ground water within a 1-mi (2-km) radius of the site (TAC, 1994). The shallow, unconfined aquifer seldom is used in the area for domestic (potable) purposes because it yields water slowly and the water is of poor quality (Seiler and Waddell, 1984).

Water in the deep, confined (artesian) aquifer is suitable for public and industrial use (see Section 2.2.3).

Residences and small businesses in the site vicinity use the municipal water supply system. Some residences located about 0.25 mi (100 m) west and downgradient from the site (on south 1100 West Street) use domestic wells completed in the deep, confined aquifer (from 100 to 300 ft [30 to 90 m] below the land surface). None of these wells are used for drinking water. One well irrigated a garden, but appears to be sanded up, producing only a trickle of water.

City (South Salt Lake) waterlines serve the former mill site area and the area east of the site. The city obtains water from five operating water wells completed in the confined (artesian) aquifer city limits (Figure 2.1). The municipal water supply wells are 800 to 1000 ft (240 to 300 m) deep, but generally are perforated from 400 to 800 ft (120 to 240 m).

Water from the wells is pumped to an underground reservoir (at 1300 East Street), where it is gravity-fed into the waterlines. The state of Utah samples and tests the water monthly. Other than transient coliform contamination, the water has always met drinking water standards. Therefore, no water treatment is necessary except chlorination. Water Conservancy District waterlines serve areas west of the site. The Water Conservancy District uses Salt Lake City or county water wells.

In 1985, the CVWRF sold the water rights to four on-site wells to the city of South Salt Lake. The Vitro Uranium Company once owned these wells. One of these wells, a 10-inch (25-centimeter [cm])-diameter cased well, is in the

southeastern portion of the site. The city is considering developing this well as a source for the municipal water supply system, but the well casing has been found to be in poor condition. The city has water rights for 2.67 cubic ft (ft³) (0.08 cubic meter [m³]) per second. The remaining three on-site water wells have been abandoned.

Because the state of Utah is concerned about the potential movement of contamination into the confined aquifer beneath the site, any pumping from the on-site water well will be limited to prevent gradient reversal. Before full-scale production pumping begins, a geophysical survey must be completed to ensure well integrity. Water quality in the well will be evaluated every 6 months. During the first 6 months of pumping, the flow will be limited to 1 ft³ (0.3 m³) per second and drawdown shall not exceed 60 ft (18 m) below ground surface. The water will be retested after 6 months of pumping. If the surrounding site monitoring wells (deep, confined monitor well(s) need to be installed) and the ground water chemistry and water levels show no signs of contamination or significant drawdown, pumping will continue for another 6 months. Thereafter, the state of Utah may increase the production rate. The state may restrict pumping if the well shows negative impacts from drawdown and/or if the water chemistry changes. However, the city of South Salt Lake is considering abandoning the water well and transferring of the water rights to an off-site location.

The city of South Salt Lake supplies irrigation water for about 25 ac (10 ha) of grass at the driving range at the former mill site. However, the treated water obtained from the CVWRF is designated for future irrigation of the driving range. The driving range uses approximately 1 acre-foot for irrigation during the summer.

2.1.3 Contaminant sources

Based on information presented in Section 1.3 of this document, as well as review of historical aerial photographs (in possession of the CVWRF) documenting former site processing activities and remedial action activities, the entire designated site is considered to have functioned as a ground water contaminant source prior to surface remediation. Site remediation consisted of removing the upper 4 to 13 ft (1.2 to 3.9 m) of contaminated surficial soils and replacing them with clean fill. However, the CVWRF reports (Dow, 1992) the continued presence of tailings underlying the CVWRF administration building and several of the sewage plant clarifiers (this has not been verified through sampling). Therefore, isolated point sources may still exist at the site. Also, a Remedial Action Program Modification (Supplemental Standards) addresses the thorium contamination left in place along the southeastern (upgradient) margin of the site.

2.2 GEOLOGY AND HYDROLOGY

2.2.1 Physical setting

The Salt Lake City Vitro site is in the lower part of the Jordan River basin. The site is located on a generally flat plain, gently sloping to the northwest between the Wasatch Mountain front to the east and the Oquirrh Mountains to the west. The Wasatch front is the regional eastern boundary of the Basin and Range Province.

2.2.2 Geology

The lithology underlying the Salt Lake City Vitro site consists of a thick sequence of Quaternary lacustrine-fluvial deposits with minor alluvial overburden. Unconsolidated lacustrine deposits below the site are approximately 700 ft (210 m) thick (Arnow et al., 1970). Tertiary deposits underlie the Quaternary deposits to a depth of approximately 1200 ft (370 m) (Mattick, 1970).

Borehole samples from previous investigations (Figure 2.2) indicate the shallow materials consist of unconsolidated silt, clayey-silt, silty-clay, and lenticular sands deposited in a fluvial-lacustrine environment. These sediments are complexly interbedded and correlation between individual boreholes is sometimes difficult. However, a grey clay layer up to 3 ft (1 m) thick generally is present 12 to 15 ft (4 to 5 m) below the ground surface beneath the entire site and the CVWRF. Figure 2.3 shows a geologic cross section of the site. Borehole data suggest siltier and more clayey sediments are found in the southern and eastern portions of the site (monitor wells 130 to 133), and sandier sediments occur in the northern and western portions of the site (monitor wells 134 and 135). Figure 2.2 shows the monitor well locations.

2.2.3 Ground water hydrology

The ground water regime in the Salt Lake City Vitro site vicinity generally is characterized by two aquifer systems: a shallow, unconfined system and a deeper, confined system. Interbedded layers of low-permeability clays and silts separate the two aquifers. Wells 70 to 330 ft (20 to 100 m) below the ground surface are under substantial artesian pressure, with ground water flowing from several wells. Near the site, ground water in both aquifers flows predominantly west-northwest, toward the Great Salt Lake.

Shallow unconfined aquifer

In the former tailings pile vicinity, the upper, unconfined aquifer is approximately 45 ft (14 m) thick. Ground water yields from the interbedded strata of this aquifer system depend on the lithology of the screened interval. Results from DOE on-site aquifer pumping tests conducted in July 1992 indicate ground water yields can range from much less than 1 gallon (gal) (4 liters [L]) per

Figure 2.2
Geologic Cross Section, Monitor Well, and Borehole Locations
Salt Lake City, Utah, Vitro Processing Site

MAC: SITE/SLC/WSAP/SITELOC&X-SECLINE

DOE/AL/62350-99
REV. 1, VER. 3

21-Jun-95
003D3WP.DOC (SLC)

Figure 2.3
Geologic Cross Section D-D'
Salt Lake City, Utah, Site

MAC: SITE/SLC/WSAP/GEOS-SEC(D-D')

DOE/AL/62350-99
REV. 1, VER. 3

21-Jun-95
003D3WP.DOC (SLC)

minute from the silts and clays to long-term sustained yields of more than 4 gal (16 L) per minute from the fine-grained sands and silty sands (Calculation No. SLC-07-92-14-03-00) (TAC, 1992).

The major sources of recharge to the unconfined aquifer are precipitation infiltration and upward leakage from the confined aquifer. Ground water in the unconfined aquifer generally discharges to surface water drainages such as Mill Creek, possibly the Vitro ditches, and the Jordan River (Figure 2.2). However, a highway drain below the Denver & Rio Grande Western Railroad/3300 South Street overpass locally influences ground water flow in the unconfined aquifer. A lift station pumps ground water entering the drain into a drain line that discharges into the head of the South Vitro Ditch. Ground water levels in the area indicate an apparent ground water divide in the southeastern corner of the site caused by the drain pumpage, drawing ground water from that area toward the drain (Figure 2.4).

A 28-acre (11-ha) golf driving range was constructed on the southeastern portion of the site in 1993. In February 1994, a ground water level monitoring program at the Vitro site began evaluating the effects of irrigating the golf driving range on ground water elevations in the unconfined aquifer and the potential impacts of irrigating a planned nine-hole golf course expansion at the site. The concerns resulted because increased water levels in the aquifer can alter the ground water flow regime, resulting in contaminants migrating off of site or discharging to bodies of surface water in the area. Preliminary results indicate the occurrence of minor seasonal mounding in response to the irrigation, but the effects appear minimal compared to the effects of precipitation.

Ground water levels in the unconfined aquifer range from 5 to 15 ft (1.5 to 4.6 m) or more below the ground surface. The water table is highest in March or April and lowest in mid-to-late summer. This seasonal pattern also is observed in the confined aquifer, which in the northern part of the valley also reaches its seasonal high in March or April and its low in mid-to-late summer (Hely et al., 1971). Topographic lows east of the site near the railroad tracks are perennially marshy. Also, construction of the golf driving range has increased topographic lows on the site. The ground water flows primarily from southeast to northwest. Figure 2.4 is a water table map of the shallow unconfined aquifer.

Figure 2.4 illustrates apparent flow directions based primarily on the regional ground water flow regime. Numerous man-made structures in the site vicinity, as well as on the site, impact local ground water flow directions in the unconfined aquifer. The interaction of these man-made structures with the natural conditions is not clearly understood. The major man-made structures at the site influencing ground water flow are:

- Site remediation, which consisted of removing and hauling away the upper 4 to 13 ft (1.2 to 3.9 m) of contaminated soils and replacing them with clean,

Figure 2.4
Ground Water Table Contours of the Unconfined Aquifer
Salt Lake City, Utah, Vitro Processing Site

500 0 500 1000 Feet

150 0 150 300 Meters

sandy fill material, thereby destroying the natural hydrostratigraphy of the upper section of the unconfined aquifer.

- A highway drain 400 ft (122 m) from the southeastern corner of the site, which locally influences ground water flow in the unconfined aquifer. A lift station pumps ground water and storm water entering the drain into a drain line that discharges into the head of the South Vitro Ditch. Ground water flow into the infiltration gallery of the lift station produces an apparent, localized ground water gradient reversal.
- Mill Creek, which in conjunction with a series of ditches on the site and in the site vicinity (that intersect the water table), and coupled with buried sewer mains 15 to 20 ft (4 to 6 m) below land surface that traverse the site within the upper saturated section of the unconfined aquifer, has resulted in a localized, complex flow pattern. The potential exists for localized ground water gradient reversals within the site boundaries.
- The golf driving range and potential expansion of the golf course, with associated current irrigation in the southeastern portion of the site, which affect the local recharge to the unconfined aquifer, thus potentially impacting the direction of contaminant migration.
- Additional clarifier facilities at the CVWRF immediately north of the site, which have required a foundation excavation of 15 to 20 ft (4 to 6 m) coupled with ground water pumping by two construction dewatering wells. The unconfined aquifer is being dewatered in this area at a rate of approximately 300 gal (1,136 L) per minute. This pumping is scheduled to continue through May 1996. The pumped water is routed through the CVWRF sewer treatment plant. Additional construction dewatering also may occur near the northwestern corner of the CVWRF for planned excavations for facility expansion near the plant discharge point into Mill Creek.

Additional site investigations and monitoring will be required to understand fully the impacts of these man-made structures on local ground water flow and contaminant migration at the site.

The hydraulic conductivities, determined from slug tests and a 1992 aquifer pumping test, ranged from 0.37 to 8.9 ft (0.11 to 2.7 m) per day (Calculation No. SLC-07-92-14-03-00) (TAC, 1992). A range of average linear ground water velocities in the shallow unconfined aquifer was calculated using the range of hydraulic conductivities, a hydraulic gradient of 0.005, and an assumed effective porosity of 0.20. Using Darcy's Law, the average linear velocity for ground water flow in the shallow unconfined aquifer ranges from approximately 3 to 80 ft (1 to 25 m) per year.

Confined aquifer

The confined aquifer begins approximately 70 ft (20 m) below the ground surface; the ground water is under substantial artesian pressure. Hydraulic head levels range from approximately 8 ft (2.5 m) above ground surface for the well screened at 70 ft (20 m) to 15 ft (4.5 m) above ground surface for the wells screened at a depth of approximately 130 ft (40 m). At the water well in the southeastern portion, the head level is approximately 12 ft (4 m) above ground level. Near the Jordan River, this confined aquifer system extends 500 to 800 ft (150 to 240 m) below the ground surface (Hely et al., 1971).

The major source of recharge to the confined aquifer is precipitation infiltration and snowmelt along the flanks of the Wasatch and Oquirrh Mountains. Beneath the site, the ground water in this aquifer flows west-northwest. Natural discharge is upward to the unconfined aquifer system. Artificial discharge includes pumpage of wells completed in the confined aquifer system. A potentiometric contour map of the deeper, confined aquifer was not constructed because there were too few data to contour and the head levels are a function of the depth of completions.

The good water quality of the confined aquifer is maintained by the upward hydraulic gradient between the two aquifers, which prevents downward migration of generally poor-quality water from the unconfined aquifer. The potential for contamination of the confined aquifer exists, however, if hydraulic head in the confined aquifer declines as a result of pumpage that reverses the direction of flow between the two aquifers. Localized water could percolate from the shallow, unconfined aquifer into the confined aquifer in the area of the cone of depression caused by large-scale pumping from wells developed in the confined aquifer. However, due to the aquifer heterogeneity, the actual effects of large-scale pumping are difficult to predict with available data.

2.2.4 Surface water hydrology

Three surface water bodies flow near or across the Salt Lake City site. The Jordan River is about 1500 ft (460 m) west of the site and flows north to the Great Salt Lake. Mill Creek, a perennial stream, flows along the northern edge of the site. This creek empties directly into the Jordan River. The flowing drainage on the Salt Lake City site includes the west-flowing Vitro Ditch, which flows through a drain line across the north side of the southeastern portion of the site (Figure 2.2). The South Vitro Ditch also crosses the site, flowing south to north, joining the Vitro Ditch near monitor well 135, and flowing west to the drain line that discharges into Mill Creek at the northwestern corner of the site. The site contributes runoff to the ditches only during severe rains. Ground water elevations in monitor wells near the South Vitro Ditch are near or below the bottom of the ditch bed; therefore, the ditch probably is not recharged continuously by ground water.

2.3 WATER QUALITY

2.3.1 Background water quality

Background water quality is defined as the quality of water if uranium milling activities had not occurred. Two hydrologic systems are at the site: a shallow, unconfined aquifer and a deeper, confined aquifer. The unconfined aquifer clearly has received contaminants from the former tailings piles and ponds. In contrast, the confined aquifer was sampled near the property boundaries to the southeast, northeast, north, and west (Figure 2.2), and radioactive constituents or metals that could be associated with tailings have not been found at levels above background determined for the unconfined aquifer (Table 2.1).

None of the DOE monitor wells in the confined aquifer are designated as background because the local ground water flow direction is not known in the confined aquifer. The total dissolved solids (TDS) water quality data in the confined aquifer at the site range from 251 to 1400 milligrams per liter (mg/L) (DOE, 1994) (Table 2.1). The more saline water was found in monitor well 005, on the west side of the site. This monitor well water has the highest sulfate and chloride levels of the four confined aquifer monitor wells. Historical data also show higher sulfate, chloride, and TDS levels in the area west of the site, within the confined aquifer. The concentrations of uranium, molybdenum, and other metals are low in monitor well 005 and the other confined aquifer wells, with a range about equal to the unconfined aquifer background well (007). Thus, the lack of uranium and molybdenum above background suggests that the higher salinity in the confined aquifer west of the site is due to natural variability.

A former Vitro water production well, now owned by the city of South Salt Lake and being considered as a municipal water supply, is capable of producing water from the confined aquifer beneath the site. This flowing well is 848 ft (258 m) deep in the southeastern portion of the site (Figure 2.2). Table 2.2 summarizes water quality data from samples taken during testing of this well in February 1985 and July 1989. The data were obtained from the Utah Division of Drinking Water. The city water well produces from a much larger and deeper portion of the confined aquifer and may represent an average of the natural vertical variation in water quality of the confined aquifer. The water chemistry falls within the range of DOE monitor wells sampled in the confined aquifer. The water was not analyzed for uranium; however, gross alpha measurements indicate uranium concentration are less than 2 picocuries per liter, which is equivalent to less than 0.003 mg/L of natural uranium. Thus, the ability of the upward hydraulic gradient to prevent downward contaminant migration is verified by this well's lack of site-related contaminants.

In the unconfined aquifer, DOE off-site monitor well 007 is located northeast and crossgradient to the site. Monitor well 007 is completed from 26 to 28 ft (7.9 to 8.5 m) below the surface and has been sampled repeatedly since 1990.

Table 2.1 Water quality of the confined aquifer, Salt Lake City, Utah, site

Parameter	Monitor well			
	001	002	003	004
Alkalinity ^a	262	282	242	200
Aluminum	<0.1	<0.1	<0.1	<0.1
Ammonium	4.3	6.7	4.6	10.7
Antimony	<0.003	<0.003	<0.003	<0.003
Arsenic	<0.01	<0.01	<0.01	<0.01
Barium	0.1	0.1	0.2	0.4
Beryllium	<0.01	<0.01	<0.01	<0.01
Cadmium	<0.001	<0.001	<0.001	<0.001
Calcium	63	40	55	122
Chloride	18	8	19	207
Chromium	<0.01	<0.01	<0.01	<0.01
Cobalt	<0.05	<0.05	<0.05	<0.05
Copper	<0.02	<0.02	<0.02	<0.02
Fluoride	0.2	0.3	0.2	0.2
Iron	0.08	0.58	0.17	0.74
Lead	<0.01	<0.01	<0.01	<0.01
Magnesium	23	20	21	60
Manganese	0.07	0.11	0.06	0.58
Mercury	<0.0002	<0.0002	<0.0002	<0.0002
Molybdenum	<0.01	<0.01	<0.01	<0.01
Nickel	<0.04	<0.04	<0.04	<0.04
Nitrate ^b	<1.0	<1.0	<1.0	<1.0
pH	7.9	7.6	7.8	7.4
Potassium	7	11	5	17
Radium-226 (pCi/L)	0.1	0.1	0.0	0.4
Radium-228 (pCi/L)	1.4	0.5	0.0	1.5
Selenium	<0.005	<0.005	<0.005	<0.005
Silver	<0.01	<0.01	<0.01	<0.01
Sodium	20	35	20	36
Strontium	0.7	0.4	0.7	1.2
Sulfate	33	<0.1	29	230
Sulfide	0.3	<0.1	<0.1	<0.1

Table 2.1 Water quality of the confined aquifer, Salt Lake City, Utah, site (Concluded)

Parameter	Monitor well			
	001	002	003	004
Thallium	<0.01	<0.1	<0.01	<0.01
Thorium-230 (pCi/L)	0.0	0.0	0.0	0.0
Tin	<0.005	<0.005	<0.005	<0.005
Total dissolved solids	NA	308	251	NA
Uranium	0.0003	0.0003	0.0003	0.0003
Vanadium	0.01	0.01	0.01	<0.01
Zinc	<0.005	<0.005	<0.005	<0.005

^aAlkalinity as milligrams per liter CaCO₃.

^bNitrate expressed as NO₃.

- Notes: 1. Filtered samples collected 8 August 1990, at the site periphery.
2. Results of the most recent complete sampling round.
3. All data in milligrams per liter unless noted as picocuries per liter (pCi/L).

NA - not available.

Table 2.2 Ground water quality data, city of South Salt Lake proposed municipal water supply well, Salt Lake City, Utah, site

Parameter	Concentration	
	August 1989 (mg/L)	February 1985 (mg/L)
Aluminum	NA	NA
Ammonium	<0.3	NA
Antimony	NA	NA
Arsenic	<0.001 ^a	<0.001
Barium	0.03 ^a	0.03
Beryllium	NA	NA
Boron	0.03	0.06
Cadmium	<0.001 ^a	<0.001
Calcium	51	66
Chloride	12	10
Chromium	<0.001 ^a	0.002
Cobalt	NA	NA
Copper	<0.01 ^a	<0.01
Cyanide	NA	NA
Fluoride	0.32	0.36
Iron	<0.03 ^a	0.15 ^a
Lead	<0.001	<0.001
Magnesium	20	20
Manganese	70	80
Mercury	<0.02 ^a	<0.02 ^a
Molybdenum	NA	NA
Nickel	<0.03 ^a	<0.01
Nitrate as NO ₃	<0.09	<0.04
Potassium	2	2
Selenium	<0.001 ^a	<0.001
Silver	<0.001 ^a	<0.001
Sodium	22	23
Strontium	NA	NA
Sulfate	80	108
Sulfide	NA	NA
Thallium	NA	NA
Tin	NA	NA

Table 2.2 Ground water quality data, city of South Salt Lake proposed municipal water supply well, Salt Lake City, Utah, site (Concluded)

Parameter	Concentration	
	August 1989 (mg/L)	February 1985 (mg/L)
Uranium	NA	NA
Vanadium	NA	NA
Zinc	<0.01 ^a	<0.001
Radionuclide	(pCi/L)	(pCi/L)
Lead-210	NA	NA
Polonium-230	NA	NA
Radium-226	NA	NA
Thorium-230	NA	NA
Gross alpha	<2	<2
Gross beta	<3	<3

^aUnfiltered water quality data. All other data are for filtered samples.

NA - not available.

TDS values in ground water from monitor well 007 range from 500 to 600 mg/L, which is actually less saline than normal for the shallow aquifer. Regionally, the TDS values in the unconfined aquifer average about 1250 mg/L. In the site vicinity, shallow ground water TDS values range from 1000 to 2000 mg/L (Seiler and Waddell, 1984).

The relatively low salinity of ground water in well 007 may be caused by aerial variations in salinity or the vertical salinity gradient in the shallow unconfined aquifer. In the areas near monitor well 007, ground water salinity increases dramatically in the upper 20 ft (6 m) of the aquifer. In the well cluster associated with monitor well 007 (wells 002, 007, 107, and 157, all sampled in 1983) salinities vary from 290 mg/L within the confined aquifer at 120 ft (37 m) below land surface to 4600 mg/L near the top of the unconfined aquifer at 8 ft (2.4 m) below land surface.

As discussed in Section 2.2.3, the unconfined aquifer probably is recharged by vertical leakage of ground water from the confined aquifer and surface recharge from precipitation, surface water flows, and irrigation. The naturally occurring increased salinity near the top of the unconfined aquifer probably represents dissolved solids concentrated by evapotranspiration. Therefore, the relatively low salinity of well 007 (compared with regional ground water) may be due to its completion in the deeper, lower-salinity portion of the unconfined aquifer and due to the influence primarily of recharge from the confined aquifer. The water chemistry supports this. For example, sulfate concentrations in well 007 (3.6 mg/L) are more similar to the confined aquifer ground waters (sulfate of <0.1 mg/L in nearby well 002) than surface water (sulfate of 173 mg/L in nearby Mill Creek).

Ground water in monitor well 007 is a sodium bicarbonate-type water; it is in equilibrium with calcium carbonate, magnesium carbonate, and barium sulfate (barite). The pH is slightly basic (near 8) and the Eh is oxidizing (390 millivolts).

Table 2.3 provides a statistical range of water quality data for wells completed in the unconfined aquifer. These data include results from the most recent sampling event (December 1994).

Most constituents commonly associated with ground water contamination from uranium mill tailings are below the detection limit in well 007. However, two constituents commonly associated with uranium mill tailings, arsenic and ammonium, are present at levels above detection in the background ground water in this well. Arsenic is known to occur naturally in the shallow aquifer throughout the region. Regionally, arsenic averages about 0.05 mg/L. Possible sources include the past use of arsenic-bearing pesticides, flue dust from copper smelters, and Quaternary sediments derived from arsenic-bearing sulfide deposits in the mountains east and southeast of the site. In well 007, arsenic averaged about 0.05 mg/L and ammonium averaged 7.7 mg/L since 1990.

Table 2.3 Comparison of background and site-related contaminated filtered ground water quality in the unconfined aquifer at Salt Lake City, Utah, 1990-1995

Parameter	Range in background		Range in contaminated ground water	
	minimum	maximum	minimum	maximum
<i>Inorganic Constituents</i>				
Alkalinity	298	495	326	1178
Aluminum	<0.05	0.10	<0.05	0.40
Ammonium (well 008)	6.1	11.8	10.9	20.9
Antimony	<0.003	0.025	<0.003	0.027
Arsenic	0.027	0.061	<0.025	0.145
Barium (well 134)	0.10	0.12	0.44	0.61
Beryllium	<0.001	<0.01	<0.001	<0.01
Cadmium	<0.001	<0.001	<0.001	0.001
Calcium (well 008)	11	13	29	426
Chloride	56	74	2540	2830
Chromium	<0.003	<0.05	<0.003	<0.02
Cobalt	<0.003	<0.05	<0.003	<0.10
Copper	0.003	<0.02	<0.002	0.04
Fluoride (well 109)	0.7	0.8	2.0	2.7
Iron (well 109)	0.04	0.25	1.5	6.48
Lead	<0.001	<0.010	<0.003	0.008
Magnesium (wells 135 - 136)	32	35	757	907
Manganese (well 109)	0.03	0.04	0.11	0.63
Mercury	<0.0001	<0.0002	<0.0001	0.0002
Molybdenum (well 131)	<0.004	0.01	<0.01	1.39
Nickel	0.007	<0.04	<0.006	<0.08
Nitrate	<1.0	5.5	<0.2	4.6
pH	7.9	8.2	6.5	8.0
Oxidation-reduction potential (Eh)	390	390	102	431
Potassium (wells 135 - 136)	26	32	176	308
Selenium	<0.001	<0.005	<0.001	0.030
Silver	<0.0002	<0.010	<0.0002	0.041
Sodium	129	150	2490	3160
Strontium	0.2	0.55	4.16	4.39
Sulfate	<0.1	3.6	4970	5560
Sulfide	<0.1	2.3	<0.1	2.1
Thallium	<0.005	<0.067	<0.005	<0.34
Tin	<0.005	0.006	<0.005	<0.100
Total dissolved solids	530	574	327	14,500
Uranium (well 109)	<0.0001	0.009	0.160	0.266
Vanadium	<0.005	<0.010	<0.010	0.071
Zinc	<0.005	0.018	<0.005	0.187
<i>Radionuclides</i>				
Radium-226	0.0	0.5	0.1	1.3
Thorium-230	0.0	0.9	0.0	0.8

- Notes:
1. Inorganic constituent concentrations reported in milligrams per liter. Radionuclide concentrations reported in picocuries per liter, Eh in millivolts, and pH in standard units.
 2. Background well is well 007. Plume concentrations are from DOE wells 008, 011, 109, 131, 132, 133, 134, 135, and 136.
 3. Constituents in boldface type are identified in the Baseline Risk Assessment (DOE, 1994) as being elevated in plume wells compared with background well 007 at the 0.05 level of significance. For these constituents, concentrations in the most contaminated well are presented.

2.3.2 Ground water contaminant delineation

The original tailings solutions within the tailings piles and evaporation ponds were acid solutions (pH less than 4) composed predominantly of aluminum sulfate and sodium chloride (Markos and Bush, 1982). Previous geochemical studies demonstrated that as the solutions migrated into the unconfined aquifer, they were immediately neutralized at the tailings-soil interface by the reaction of calcite and dolomite with the acid solution. This produced a thin zone of precipitates at the interface. This 4-inch (10-cm) zone included gypsum, iron oxides, and basic iron and aluminum sulfates (Markos and Bush, 1982).

As a result of neutralization, precipitation, and pH-dependent sorption, contaminated ground water within the unconfined aquifer contains relatively low concentrations of heavy metals and metalloids. The ground water contamination is recognized primarily by high concentrations of TDS and major ions including sulfate, chloride, calcium, magnesium, and sodium. Locally, the alkalinity is very high (about 1100 mg/L as calcium carbonate in well 135), reflecting the neutralization of the acid tailings solutions by carbonates. Compared to background waters, several trace elements are present at elevated concentrations, including manganese, molybdenum, uranium, strontium, and silver.

Ground water contamination varies both over time and area across the site. In 1983, the highest sulfate concentration was in the western portion of the site. Currently, the highest concentrations of sulfate (Figure 2.5) and chloride occur in the central portion of the site, near monitor well 135, the area that was once the site of evaporation ponds; west of the site (in monitor wells 011 and 109), sulfate and chloride concentrations have decreased over time. However, in monitor wells 011 and 109, uranium and molybdenum concentrations have remained constant or have increased during the same period, indicating that a lower-salinity contamination is replacing a higher-salinity contamination along the western portion of the site. This change could be related to the physical disturbance of the site during surface remediation, the flow of ground water in bedding gravels beneath a sewer main in this area, and/or the former presence of a free-flowing well completed in the confined aquifer in this area.

Comparing sulfate and chloride concentrations (1983 data) from well clusters in the contaminated area with those concentrations in the background well cluster demonstrates that contamination extends at least 30 ft (9 m) below land surface within the unconfined aquifer. Chloride and sulfate concentrations that do not decrease with increasing depth demonstrate the vertical extent of contamination. Data from two on-site wells (now removed) screened between 54 and 68 ft (16.5 to 20.1 m) below land surface did not indicate contamination in 1983. Therefore, available data indicate that contamination probably is limited to depths of less than 50 ft (15 m).

Figure 2.5
Approximate Extent of Sulfate Contamination (1992-1993 Data)
Salt Lake City, Utah, Vitro Processing Site

Recent chemical data (December 1994) from monitor wells 130, 132, and 133 indicate contamination has affected the southern and eastern site boundaries. It is not completely understood what localized conditions influenced the appearance of contaminants in these historically clean wells. However, a combination of the previously discussed man-made conditions are believed to have impacted the localized, natural system. In the southeast corner of the site, monitor well 131 shows an increase in sulfate, sodium, chloride, uranium, and molybdenum levels. This well is near the old mill site, adjacent to the underpass of State Route 171 beneath the Denver & Rio Grande Western Railroad. As discussed earlier, the underpass excavation created a gradient reversal in the area (DOE, 1984), and contaminated water appears to be moving southeast, toward the underpass.

The lateral extent of the contamination is unknown downgradient of the site, to the west and north. Contaminants have migrated beyond the existing monitor wells in these areas (wells 109, 011, 008, and 134). Extrapolating the existing chemical gradients could estimate the downgradient extent of the plume. However, there are too few existing wells, combined with the possible influence of man-made structures, for such an extrapolation to be meaningful.

Table 2.3 summarizes the water quality data in the unconfined aquifer between 1990 and 1995. The following constituents were elevated statistically above background: ammonium, barium, calcium, chloride, fluoride, iron, magnesium, manganese, molybdenum, potassium, radium-226, silver, sodium, strontium, sulfate, and uranium. For an expanded discussion of the contaminant distribution, review the 1994 Baseline Risk Assessment for the Salt Lake City site (DOE, 1994).

2.3.3 Surface water and sediment sampling

Currently the South Vitro Ditch drains the western two-thirds of the site and the Vitro Ditch drains the eastern one-third. The Vitro Ditch receives waters from a drain line and storm sewer on the Denver & Rio Grande Western Railroad property that drain from a marshy area immediately east of the site. The South Vitro Ditch receives waters from a drain line and storm sewer connected to the lift station at the underpass southeast of the site. The South Vitro Ditch enters a culvert near the center of the site and ultimately discharges into Mill Creek near the northwestern corner of the site. This point of discharge is immediately downstream of monitor well 134 and the CVWRF point of discharge for treated effluent. Mill Creek, in turn, discharges into the Jordan River about 1500 ft (460 m) east of the site (Figure 2.6). Four filtered and unfiltered samples were collected from Mill Creek in December 1994 (Table 2.4). Six filtered and unfiltered surface water samples from the South Vitro Ditch and the Vitro Ditch were collected in December 1994. These samples were analyzed for major elements, site-related contamination, and trace elements (including arsenic, copper, lead, and vanadium) that may be related to ambient water quality. Additional surface water samples were collected from Mill Creek and the Jordan River in December 1993. The data for Mill Creek are similar to those collected

Table 2.4 Summary of Mill Creek surface water quality data, December 1994, Salt Lake City, Utah, site

Parameter	Upstream location 180		Downstream location 182	
	Filtered	Unfiltered	Filtered	Unfiltered
<i>Inorganic constituents</i>				
Alkalinity as CaCO ₃	NA	225	NA	244
Aluminum	<0.05	0.13	<0.05	<0.05
Ammonium	NA	0.26	NA	0.79
Arsenic	<0.005	<0.005	0.006	0.006
Barium	<0.10	<0.10	<0.10	<0.10
Calcium	116	NA	93	NA
Chloride	NA	122	NA	279
Chromium	<0.01	<0.01	<0.01	<0.01
Copper	<0.02	<0.02	<0.02	<0.02
Fluoride	NA	0.22	NA	0.63
Iron	<0.03	0.26	0.04	0.10
Lead	<0.003	<0.003	<0.003	<0.02
Magnesium	39	NA	42	NA
Manganese	0.02	0.02	0.03	0.03
Molybdenum	<0.01	<0.01	0.01	0.02
pH	NA	7.94	NA	6.92
Potassium	4.0	NA	20.7	NA
Silica	21	20	23	22
Silver	<0.0002	<0.0002	0.0002	0.0005
Sodium	71	NA	180	NA
Strontium	1.1	1.1	0.94	0.92
Sulfate	NA	138	NA	133
Total dissolved solids	729	NA	960	NA
Uranium	0.001	0.002	0.007	0.007
Vanadium	<0.01	<0.01	<0.01	<0.01
<i>Radionuclide</i>				
Radium-226	0.1	0.1	0.0	0.1

Note: Inorganic concentrations in milligrams per liter, except for pH (standard units). Radionuclide radium-226 in picocuries per liter.

NA – not analyzed

< indicates less than the given method detection limit.

in 1994, but include fewer analytes. Data for the Jordan River indicate no presence of site-related contamination in the river. The results of these samples are more fully discussed in the Baseline Risk Assessment (DOE, 1994) (Table 2.5).

Sediment samples also were collected from Mill Creek and the South Vitro Ditch in December 1993 and 1994 and from the Vitro Ditch on the Denver & Rio Grande Western Railroad property in December 1994. Samples were collected and analyzed for site-related contaminants (Table 2.6) (calcium, chloride, magnesium, radium-226, silver, sodium, strontium, sulfate, and uranium) and elements that may be related to ambient sediment chemistry (arsenic, chromium, copper, lead, and vanadium).

2.4 SITE CONCEPTUAL MODEL

From 1951 to 1964, the Salt Lake City plant processed uranium ore by acid leaching. In 1965, the mill converted to the production of vanadium. Vanadium production ceased in 1968 and the plant was dismantled in 1970 (see Section 1.3). Remedial action at the Salt Lake City site occurred from 1985 to 1987. A total of 2,798,000 yd³ (2,139,000 m³) of tailings along with up to 13 ft (4 m) of excavated materials were removed from the site during that time period. The CVWRF board currently owns the 128-acre (52-ha) former Vitro processing site. A 28-acre (11-ha) southeastern portion of the site has been leased and developed into a golf driving range. The remaining land is vacant but may be developed as a commercial area, residential area, or golf course.

The near-surface geology of the Salt Lake City site consists of Quaternary lacustrine-fluvial deposits with minor alluvial overburden and shallow fill materials. These unconsolidated deposits reach a thickness of 700 ft (210 m) underlying the site. The ground water regime in the site vicinity generally is characterized by two aquifer systems: a shallow, unconfined system (0 to 45 ft [0 to 4 m] deep) and a deeper, confined system. Interbedded layers of low-permeability clays and silts separate the two aquifers. Wells completed 70 to 330 ft (20 to 100 m) below ground surface are under substantial artesian pressure, with ground water flowing from several wells. Near the site, ground water in both aquifers flows predominantly west-northwest, toward the Great Salt Lake.

The major sources of recharge to the confined aquifer are precipitation infiltration and snowmelt along the flanks of the Wasatch and Oquirrh Mountains. Beneath the site, the natural ground water discharge from the confined aquifer is upward to the unconfined aquifer system. Ground water discharge from the unconfined aquifer is generally to surface water drainages such as Mill Creek and the Jordan River. Ground water levels in the unconfined aquifer range from 5 to 15 ft (1.5 to 4.6 m) or more below the ground surface. The water levels are highest in March or April and lowest in mid-to-late summer.

Table 2.5 Summary of Vitro Ditch and South Vitro Ditch surface water quality data, December 1994, Salt Lake City, Utah, site

Parameter	South end of South Vitro Ditch (on the site)		Confluence of South Vitro and Vitro ditches		Vitro Ditch (east of site)	
	Location 186		Location 187		Location 191	
	filtered	unfiltered	filtered	unfiltered	filtered	unfiltered
<i>Inorganic Constituents</i>						
Alkalinity as CaCO ₃	NA	296	NA	267	NA	85
Aluminum	<0.05	0.12	<0.05	0.71	<0.05	1.68
Ammonium	NA	0.61	NA	0.63	NA	0.31
Arsenic	<0.005	0.028	<0.005	0.022	<0.005	0.008
Barium	<0.10	<0.10	<0.10	0.10	<0.10	0.11
Calcium	79	NA	93	NA	76	NA
Chloride	NA	240	NA	324	NA	769
Chromium	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	<0.02	<0.02	<0.02	0.03	<0.02	0.03
Fluoride	NA	0.68	NA	0.66	NA	0.35
Iron	<0.03	0.21	<0.03	1.18	0.12	2.11
Lead	<0.003	<0.003	<0.003	0.014	<0.003	0.021
Magnesium	56	NA	63	NA	34	NA
Manganese	0.04	0.04	0.06	0.08	0.15	0.16
Molybdenum	0.12	0.12	0.14	0.13	0.01	0.01
pH	NA	7.53	NA	7.55	NA	7.43
Potassium	22.4	NA	24.7	NA	10.6	NA
Silica	21	22	23	24	7	17
Silver	<0.0002	<0.0002	<0.0002	0.0003	0.0002	0.0004
Sodium	200	NA	250	NA	510	NA
Strontium	0.87	0.84	0.90	0.88	0.61	0.61
Sulfate	NA	179	NA	242	NA	138
Total dissolved solids	1040	NA	1220	NA	1710	NA
Uranium	0.024	0.023	0.037	0.028	0.008	0.008
Vanadium	0.04	0.04	0.03	0.03	<0.01	<0.01
<i>Radionuclide</i>						
Radium-226	0.3	0.3	0.3	0.3	0.1	0.2

Note: Inorganic constituent concentrations in milligrams per liter, except for pH (standard units). Radionuclide radium-226 in picocuries per liter.

NA – not analyzed

< indicates less than the given method detection limit.

Table 2.6 Summary of Vitro Ditch and South Vitro Ditch sediment chemistry data, December 1993 and 1994, Salt Lake City, Utah, site

Parameter	South end of South Vitro Ditch (on the site)		Confluence of South Vitro and Vitro ditches		Vitro Ditch (east of site)
	Location 186		Location 187		Location 191
	Dec. 1993	Dec. 1994	Dec. 1993	Dec. 1994	Dec. 1994
Percent solids	73	61	31	30	50
<i>Inorganic Constituents</i>					
Arsenic	NA	13	NA	61	54
Calcium	69800	NA	81700	NA	NA
Chloride	41	NA	130	NA	NA
Chromium	NA	34	NA	48	42
Copper	NA	92	NA	404	141
Lead	NA	245	NA	344	485
Magnesium	3710	NA	NA	2130	NA
Molybdenum	6	13	236	158	2
Selenium	<1.4	NA	<1.4	NA	NA
Silver	<2.7	0.27	<6.4	5.6	1.4
Sodium	718	NA	1600	NA	NA
Strontium	79	NA	43	NA	NA
Sulfate	77	NA	99	NA	NA
Uranium	3.9	6	4.8	10	5
Vanadium	NA	26	NA	94	50
<i>Radionuclide</i>					
Radium-226		14.3	NA	6.8	NA 6.6

Notes: 1. Location 191 was not sampled during December 1993.
2. Inorganic constituent concentrations in milligrams per kilogram. Radionuclide radium-226 in picocuries per gram.

NA – not analyzed.

< indicates less than the given method detection limit.

As previously stated, regional ground water flow in the shallow, unconfined aquifer is west-northwest. However, several man-made structures within the site vicinity locally impact this shallow flow. The major structures are as follows:

- Site remediation which consisted of removing and hauling away the upper 4 to 13 ft (1.2 to 3.9 m) of contaminated soils and replacing them with clean, sandy fill material; thereby destroying the natural hydrostratigraphy of the upper section of the unconfined aquifer and generally increasing the shallow permeabilities.
- A lift station and drain located off the southeastern corner of the site, which locally influences ground water flow in the unconfined aquifer. The lift station pumps ground water and storm water entering the infiltration gallery into a drain line that discharges into the head of South Vitro Ditch. Ground water flow into the gallery produces an apparent, localized ground water gradient reversal.
- Mill Creek, which in conjunction with a series of ditches on the site and in the site vicinity, coupled with buried sewer mains that traverse the site within the upper saturated section of the unconfined aquifer, has resulted in a localized, complex flow pattern.
- The golf driving range and potential expansion of the golf course, which coupled with associated irrigation on the site, will positively affect the local recharge to the unconfined aquifer.
- Additional clarifiers at the CVWRF facility immediately north of the site, which have required a foundation excavation of 15 to 20 ft (4 to 6 m) coupled with pumping for dewatering. The unconfined aquifer is being dewatered in this area at a rate of 300 gal (1136 L) per minute. This pumping is scheduled to continue through May 1996. The pumped water is being routed through the CVWRF sewer treatment plant.
- Additional expansion of the CVWRF near the northwestern corner of the site, which may have a similar effect on the additional clarifiers.

The original tailings solutions within the tailings piles and evaporation ponds were acid solutions composed predominantly of aluminum sulfate and sodium chloride. Geochemical studies demonstrated that as the solutions migrated into the unconfined aquifer, they were immediately neutralized at the tailings-soil interface by the reaction of calcite and dolomite with the acid solution. As a result of this neutralization, precipitation, and pH-dependent sorption, contaminated ground water has high concentrations of TDS, sulfate, chloride, calcium, magnesium, and sodium (as opposed to trace metals, which dropped out as a result of the neutralization). However, compared to background

waters, several trace elements are present at elevated concentrations, including manganese, molybdenum, uranium, vanadium, strontium, and silver.

Currently, the highest concentrations of sulfate and chloride occur in the central portion of the site, near monitor well 135, the area that was once the site of evaporation ponds. However, to the west (in monitor wells 011 and 109), uranium and molybdenum concentrations have remained constant or have increased over time.

The extent of the contamination is unknown downgradient of the site, to the west and the north. Contaminants have migrated beyond the existing monitor wells in these areas (wells 109, 011, 008, and 134). Recent sampling results (December 1994) have indicated (for the first time) the presence of site-related contaminants in wells crossgradient to the site (wells 130, 133, and 132). During the same sampling event, surface water samples and sediments from the Vitro ditches detected the presence of site-related contaminants. Future sampling events will continue to monitor these occurrences.

The deeper, confined aquifer has not exhibited any impact as a result of site-related contamination.

3.0 DATA COLLECTION OBJECTIVES

3.1 REGULATORY REQUIREMENTS

The regulatory requirements for sampling at the site are specified in 40 CFR Part 192 (1994) and are described in the draft WSAP guidance document (DOE, 1995).

3.2 COMPLIANCE MONITORING

Currently, no compliance monitoring is required at the Salt Lake City processing site or the Clive disposal site.

3.3 SITE CHARACTERIZATION

Characterization of contaminant migration in the shallow unconfined aquifer will be an ongoing activity. Monitor wells 007 and 006 will monitor background water quality. Monitor wells 008, 130, 131, 132, 133, 134, and 136 will monitor on-site and downgradient migration of the contaminant plume.

Surface water samples also will be collected to monitor the effects of potential ground water discharge to the South Vitro Ditch. Recent sampling results have detected constituents (including uranium, molybdenum, and lead) in the Vitro ditches that may be site-related. Further sampling is required to verify the sources of these constituents.

Recent sampling of sediments from the South Vitro Ditch appears to indicate that constituents from surface waters have adsorbed into the sediments. Those constituents at elevated levels in the South Vitro Ditch include arsenic, copper, lead, molybdenum, and silver. Off-site locations fed by storm sewers need further sampling to determine if arsenic, copper, and lead are site-related or due to ambient conditions. Molybdenum and silver are site-related.

Semiannual sampling should be conducted during February through April and July through September, corresponding to the seasonal periods of high and low water tables, respectively.

4.0 DATA QUALITY REQUIREMENTS

Data quality requirements define the manner in which samples are collected, handled, and analyzed. The objectives include 1) defining analytical support levels; 2) following standard procedures for water sampling, preservation, transport, and various other field procedures; 3) performing activities in accordance with quality assurance and quality control protocols; and 4) providing analytical data validation. The WSAP guidance document (DOE, 1995) and applicable SOPs (JEG, n.d.) state the data quality objectives to be followed during data collection and evaluation activities.

5.0 SAMPLING PLAN

This section presents the sampling locations, analytes (including field analyses), and sampling frequencies for the upcoming 2 years, as well as projected sampling needs for an additional 5 years. Also presented in this section are the data evaluation methods and response to anomalous data. The projected end point for the sampling activities is when the federal and state regulatory agencies accept the ground water compliance strategy.

5.1 SAMPLING LOCATIONS

Table 1.1 lists all existing monitor wells. Ground water contamination at the site is restricted to the shallow, unconfined aquifer. Contamination does not extend into the deeper, confined aquifer, and the upward hydrologic gradient prevents contamination from reaching the confined aquifer; therefore, ground water quality in the confined aquifer will not be monitored. Contaminated ground water and background ground water will be monitored in the shallow, unconfined aquifer.

Site-related impacts to water quality have been observed in the shallow unconfined aquifer (wells 008, 130, 131, 132, 133, 134, and 136) within the area of identified contamination. These wells will be monitored to detect changes in concentrations of site-related contaminants in ground water. Such changes could signal changes in the hydrologic flow regime on the site or provide information on movement, dispersion, and attenuation of site-related contaminants. Also, while not necessarily expected, increases in the concentrations of site-related contaminants could affect interpretation of risk assessment.

Background water quality in the unconfined aquifer will be monitored in two wells (007 and 006). This will allow identification of changes in ground water quality that are not site-related. In addition, further sampling of both 006 and 007 will provide a better understanding of the range of back ground water quality in the shallow, unconfined aquifer. While background water quality in monitor well 006 has greater concentrations of both major and minor elements than in monitor well 007, available data are insufficient to characterize this difference.

No known operating domestic wells are completed in the shallow aquifer within 1 mile of the site. Therefore, there will be no routine sampling of private wells. Two private wells are owned by the CVWRF board and located at the facility. These wells are used for dewatering the shallow, unconfined aquifer during construction activities associated with the CVWRF expansion. Water from these wells will be sampled routinely while in operation to provide information on the character and movement of ground water near the pumping wells. In addition, the CVWRF may complete a third dewatering well. If completed, this well also will be sampled routinely while in operation.

Ground water samples will be collected in order of increasing contamination to minimize possible effects of equipment contamination. Table 5.1 provides this order.

Table 5.1 Order for sampling and summary of ground water monitor wells to be sampled, Salt Lake City, Utah, site

Well ID	Aquifer	Sampling justification
SLC-01-007	Unconfined	Monitor concentrations in background
SLC-01-006	Unconfined	Monitor concentrations in background
SLC-01-008	Unconfined	Monitor concentrations of contaminants
SLC-01-134	Unconfined	Monitor concentrations of contaminants
SLC-01-130	Unconfined	Monitor concentrations of contaminants
SLC-01-131	Unconfined	Monitor concentrations of contaminants
SLC-01-132	Unconfined	Monitor concentrations of contaminants
SLC-01-133	Unconfined	Monitor concentrations of contaminants
SLC-01-139	Unconfined	Private well (constructed 1981) at the CVWRF used to monitor concentrations of contaminants
SLC-01-140	Unconfined	Private well (constructed 1995) at the CVWRF used to monitor concentrations of contaminants
SLC-01-136	Unconfined	Monitor concentrations of contaminants

Four rounds of surface water samples will be collected over the next 2 years from:

- One background location (to be determined in the field by the site hydrologist, ecologist, and geochemist).
- One location along the Vitro Ditch.
- Three locations along the South Vitro Ditch.
- Four locations along Mill Creek.

The purpose is to characterize the possible effects of ground water discharge to the South Vitro Ditch and Mill Creek. Screening sampling has detected constituents (including uranium and molybdenum) in the South Vitro Ditch and Mill Creek that may be site-related. Further sampling is required to verify the concentrations of these constituents and better characterize their sources. In addition, suspended particulates containing copper, lead, and silver have been detected in the Vitro Ditch and the South Vitro Ditch, and downstream of their confluence. These locations and a background location must be sampled further to determine if these constituents are site-related or background. Table 5.2 provides the locations and sampling order.

Sampling of sediments in the South Vitro Ditch indicates that they contain concentrations of several constituents at levels greater than those expected in a

Table 5.2 Order of sampling and summary of surface water locations to be sampled, Salt Lake City, Utah, site

Well ID	Location	Sampling justification
<i>Mill Creek</i>		
SLC-01-180	Immediately upstream of Interstate 15	Background.
SLC-01-192	Immediately upstream of the CVWRF discharge	Potential area of contaminated ground water discharge.
SLC-01-193	CVWRF discharge to Mill Creek	Determine impact of CVWRF discharge.
SLC-01-182	Downstream of south Vitro Ditch discharge	Determine impact of south Vitro Ditch discharge to Mill Creek.
<i>Vitro Ditch</i>		
SLC-01-191	East of site, between Denver & Rio Grand Western Railroad tracks	Determine impact of Vitro Ditch discharge to South Vitro Ditch.
<i>South Vitro Ditch</i>		
SLC-01-194	Storm sewer discharge to South Vitro Ditch at its south end	Determine impact of storm sewer discharge.
SLC-01-186	South end of South Vitro Ditch	Monitor contaminants in south Vitro Ditch.
SLC-01-187	North end of South Vitro Ditch, downstream of Vitro Ditch discharge	Monitor contaminants in combined Vitro ditches.
<i>Other</i>		
SLC-01-195	To be determined	Marshy background location to determine background for Vitro Ditch.
SLC-01-196	Off-site storm sewer (location to be determined)	Storm sewer water in an off-site area to determine background.
SLC-01-197	Surface water pond, southeastern corner of site	Monitor for possible contaminated ground water discharge to pond.
SLC-01-198	Lift station discharge to storm sewer	Monitor quality of water withdrawal from the underpass.

normal soil or sediment. These include molybdenum, arsenic, copper, lead, and silver. One or more additional background sampling locations are required to demonstrate if these constituents are site-related or background. If it can be demonstrated, on a case by case basis, that any of these constituents is in the range of background, further sampling will not be required. If these constituents are demonstrated to be site-related, further sampling and analysis will be performed to determine their impact on the environment. These further analyses will include toxicity characteristic leaching procedure tests or similar tests to characterize the fraction of contaminants bioavailable to plants and sampling of biota to determine the amount of bioconcentration and bioaccumulation in tested organisms. Table 5.3 provides locations for sediment samples.

5.2 ANALYTE SELECTION

Analytes to be measured in ground water include major elements and field parameters as indicators of general water quality and constituents identified as site-related contaminants in ground water (DOE, 1994). Measured field parameters are alkalinity, pH, temperature, oxidation-reduction potential, and dissolved oxygen. Laboratory measurements are ammonium, barium, calcium, fluoride, iron, magnesium, manganese, molybdenum, potassium, silver, sodium, strontium, sulfate, uranium, and radium-226. Also, arsenic, copper, lead, and vanadium, while not identified as site-related contaminants, will be analyzed for comparison to ambient concentrations in background ground water. In general, filtered samples will be collected and analyzed. Unfiltered samples also will be collected and analyzed for trace metals, which may be adsorbed on suspended particulates. Table 5.4 lists the analytes to be monitored for in ground water and the justification for their sampling.

Analytes to be measured in surface water are constituents associated with ground water contamination and known to be present in surface water (based on screening sampling). These analytes are chloride, sulfate, iron, molybdenum, silver and uranium (Table 5.4). Also, arsenic, copper, lead, and vanadium, while not identified as site-related contaminants, will be analyzed for comparison to ambient conditions and to verify that these constituents came from off-site sources.

Analytes to be measured in sediments are those constituents known to be present at concentrations notably greater than those in a normal soil or sediment. Table 5.4 lists these analytes.

5.3 SAMPLING FREQUENCY

Monitoring wells, surface water, and sediments will be sampled biannually over the next 2 years. Biannual sampling is recommended because 1) contaminant concentrations have increased recently in several on-site wells and 2) several recent on-site activities have the potential to impact the ground water regime. These activities include 1) excavation, grading, and dewatering related to

Table 5.3 Summary of sediment locations to be sampled, Salt Lake City, Utah, site

Location ID	Location	Sampling justification
<i>Vitro Ditch</i>		
SLC-01-191	Marshy area east of site between Denver & Rio Grande Western Railroad tracks	Determine constituent levels in drainage to combined Vitro ditches.
<i>South Vitro Ditch</i>		
SLC-01-194	Storm sewer discharging to South Vitro Ditch	Determine constituent levels in sediments in storm sewer.
SLC-01-186	South end of South Vitro Ditch	Monitor contaminants in South Vitro Ditch.
SLC-01-187	North end of South Vitro Ditch, downstream of Vitro Ditch discharge	Monitor contaminants in combined Vitro ditches.
<i>Other</i>		
SLC-01-195	To be determined	Marshy background location to determine background.
SLC-01-196	Off-site storm sewer (location to be determined)	Determine background constituent levels in sediments in storm sewer.

Table 5.4 Summary of field parameters and laboratory analytes to be measured in ground water, surface water, and sediment, Salt Lake City, Utah, site

Analyte	Ground water	Surface water	Sediment
FIELD MEASUREMENTS			
Alkalinity	X	X	
Dissolved oxygen	X		
Oxidation-reduction potential (Eh)	X		
pH	X	X	
Temperature	X	X	
Turbidity	X	X	
LABORATORY MEASUREMENTS			
<i>Filtered samples</i>			
Ammonium	X		
Arsenic	X		
Barium	X		
Calcium	X	X	
Chloride	X	X	
Fluoride	X		
Iron	X	X	
Lead	X	X	
Magnesium	X	X	
Manganese	X		
Molybdenum	X	X	
Potassium	X		
Radium-226	X		
Silver	X	X	
Sodium	X	X	
Strontium	X		
Sulfate	X	X	
Total dissolved solids	X		
Uranium	X	X	
Vanadium	X	X	
<i>Unfiltered samples</i>			
Arsenic	X	X	X
Copper	X	X	X
Iron	X	X	
lead	X	X	X
Molybdenum	X	X	X
Silver	X	X	X
Uranium	X	X	X
Vanadium	X	X	

CVWRF expansion and 2) irrigation of the golf driving range. Biannual monitoring of ground water and surface water during this period will provide information on impacts (or lack of impacts) to ground water and surface water from these activities.

Biannual sampling will be conducted once during February through April and once during July through September, corresponding to the seasonal periods of high and low water levels (respectively) in the unconfined aquifer (DOE, 1995).

If, after 2 years, water quality has remained relatively stable and no additional construction activities are on the site, annual sampling of ground water is recommended for the following 5 years. Surface water sampling at two locations (186 and 186) will continue in the South Vitro Ditch on an annual basis. If, however, 1) ground water quality is highly variable, 2) CVWRF construction activities continue, or 3) expansion of the golf course occurs, biannual sampling of ground water and surface water at the two locations on South Vitro Ditch should continue for 3 more years to provide information on possible changes in the ground water regime flow related to these activities.

It is anticipated that sediments at all locations and surface water at locations other than 186 and 187 will be characterized sufficiently after 2 years of biannual sampling; therefore, sediment and surface water sampling at those locations will cease.

5.4 DATA EVALUATION METHODS

Sampling results will be compared with previous historical data and with background to determine changes or time-trends in concentrations of site-related contaminants. Decreases or increases in constituent concentrations will be evaluated to determine:

- 1) If evidence exists for increased or decreased levels of contamination in ground water or surface water that would affect the conclusions of the Baseline Risk Assessment (DOE, 1994).
- 2) If evidence exists of movement of contaminated ground water into areas not previously identified as being contaminated.
- 3) If evidence exists of changes in the ground water flow regime related to construction activities or irrigation.

5.5 RESPONSE TO ANOMALOUS DATA

Data that lie outside of historical ranges will be assessed to determine if the value is reasonably expected given the standard deviation of previous sampling rounds or the existence of trends. If the value is not reasonably expected, field blank and equipment blank analyses will be checked for the possibility of sample contamination, and field and laboratory records will be checked for the

possibility of a sampling or transcription error. If these are not the cases, any remaining sample will be reanalyzed to determine if the value is an analytical error. If the anomalous data cannot be shown to be due to sampling or analytical errors, the well will be resampled for the anomalous parameter during the next sampling event.

6.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this document.

Name	Contribution
B. Smith	Document coordinator
C. Yancy	Primary author
S. Wright, A. Holm	Senior technical review
T. Jackson	Geochemistry
B. Toth	Toxicology
L. Sanchez, WordCenter, Inc.	Text processing
K. Walston, V. Beck	Editing
B. Harvey	Graphic design

7.0 REFERENCES

- Arnow et al. (T. Arnow, R. Van Horn, and R. La Pray), 1970. "The Pre-Quaternary Surface in the Jordan Valley," in *Geological Survey Research 1970*, U.S. Geological Survey Professional Paper 700-D, Washington, D.C., pp. D257-D261.
- DOE (U.S. Department of Energy), 1995. *Guidance Document for Preparing Water Sampling and Analysis Plans for UMTRA Sites*, DOE/AL/62350-70F, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1994. *Baseline Risk Assessment of Ground Water at the UMTRA Salt Lake City, Utah, Site*, DOE/AL/62350-134, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1989. *Technical Approach Document*, UMTRA-DOE/AL-050425.0002, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- DOE (U.S. Department of Energy), 1984. *Processing Site Characterization Report for the UMTRA Site at Salt Lake City*, Report No. UMTRA-DOE/AL-050102.000, prepared by the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- Dow, R., 1992. Former manager, Central Valley Water Reclamation Facility, Salt Lake City, Utah, personal communication with C. Yancy, Geraghty & Miller, Inc., Albuquerque, New Mexico, March 1992.
- Hely et al. (A. G. Hely, R. W. Mower, and C. A. Harr), 1971. "Water Resources of the Salt Lake County, Utah," State of Utah Department of Natural Resources, Technical Publication No. 31, Salt Lake City, Utah.
- JEG (Jacobs Engineering Group Inc.), n.d. *Albuquerque Operations Manual*, standard operating procedures, prepared by Jacobs Engineering Group Inc., Albuquerque, New Mexico, for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.
- Markos, G., and K. J. Bush, 1982. *Geochemical Investigation of UMTRAP Designated Site at Salt Lake City, Utah*, GECR #R-826, Contract #DE-ACO4-82AL18797, Document DOE/UMT/0235, prepared by GECR, Inc., Rapid City, South Dakota, prepared for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

- Mattick, R. E., 1970. "Thickness of Unconsolidated to Semiconsolidated Sediments in Jordan Valley, Utah, in *Geological Survey Research 1970*, U.S. Geological Survey Professional Paper 700-C, Washington.
- Merritt, R. C., 1971. *The Extractive Metallurgy of Uranium*, Colorado School of Mines Research Institute, Golden, Colorado, 1971.
- Seiler, R. L. and K. M. Waddell, 1984. "Reconnaissance of the Shallow-Unconfined Aquifer in Salt Lake Valley, Utah," *Water-Resources Investigations Report 83-4272*. U.S. Geological Survey in cooperation with Salt Lake County, Salt Lake City, Utah.
- TAC (Technical Assistance Contractor), 1994. *Summary of Field Activities at Salt Lake City, May 3-5, 1994*, compiled by the Technical Assistance Contractor, Jacobs Engineering Group Inc., for the U.S. Department of Energy, UPDCC File Location No. 2.19.7, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico, May 13, 1994.
- TAC (Technical Assistance Contractor), 1992. *Salt Lake City Site Average Linear Ground Water Velocity Calculation*, SLC-07-92-14-03-00, August 6, 1992, prepared by the Technical Assistance Contractor, Jacobs Engineering Group Inc., for the U.S. Department of Energy, UPDCC File Location No. 2.19.2.7, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

CODE OF FEDERAL REGULATIONS

- 40 CFR Part 192, *Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings*, U.S. Environmental Protection Agency (1994).

FEDERAL REGISTER

- 60 FR 2854, *Groundwater Standards for Remedial Actions at Inactive Uranium Processing Sites*, final rule, U.S. Environmental Protection Agency, 11 January 1995.