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UMTRA PROJECT WATER SAMPLING AND ANALYSIS PLAN

SHIPROCK, NEW MEXICO

February 1994

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

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EXECUTIVE SUMMARY

Surface remedial action has been completed at the Uranium Mill Tailings Remedial Action (UMTRA) Project site in Shiprock, New Mexico. The tailings, contaminated soil, and debris have been contained in a disposal cell on the alluvial terrace above the floodplain on the south side of the San Juan River. No compliance monitoring is required at the disposal cell. One round of samples will be collected from the locations described below during January 1994.

Sampling planned for fiscal year 1994 consists of the following:

- Collecting ground water samples from six new monitor wells installed in 1993 on the terrace to increase the statistical basis for the water quality analyses at those wells.
- Collecting ground water samples from two previously existing monitor wells on the terrace to observe changes in water quality since construction of the disposal cell.
- Measuring water elevations in the monitor wells on the terrace to estimate the ground water flow direction; measuring the yield and recovery characteristics of the wells to assist in assessing the capacity of the alluvial and bedrock aquifers to supply water.
- Collecting ground water samples from monitor wells on the north bank of the San Juan River to assess the background ground water quality.
- Collecting ground water samples from two new wells installed in 1993 along the river's edge near the downstream end of the floodplain to increase the data base for these wells and to monitor concentrations of constituents discharging to the San Juan River.
- Collecting ground water samples from a new well installed in 1993 near the upstream end of the floodplain to increase the data base on water quality in that area.
- Collecting surface water samples from 10 locations along the San Juan River to assess water quality changes from upstream to downstream of the site during a typically low flow period.
- Collecting surface water samples at four locations on the floodplain, at the two seeps, and at one location in Bob Lee Wash.
- Measuring water levels in the monitor wells on the floodplain to predict ground water flow directions and rates.
- Analyzing filtered ground water samples from the terrace and the floodplain for antimony, arsenic, cadmium, calcium, magnesium, nickel, potassium, sodium, chromium, iron, lead, manganese, molybdenum, boron, mercury, selenium, strontium, uranium, zinc, chlorine, sulfate, fluorine, ammonium, nitrate, silica, phosphate, total dissolved solids, dissolved organic carbon, vanadium, radium-226, radium-228, and thorium-230.

- Analyzing unfiltered groundwater samples from the terrace (except those from wells 600 and 602) and the floodplain for cadmium, iron, lead, uranium, vanadium, radium-226, lead-210, polonium-210, and thorium-230.

- Analyzing filtered and unfiltered samples from the seep on the escarpment for uranium, total organic carbon, sulfate, nitrate, strontium, and selenium.

- Analyzing unfiltered samples from the surface locations and the San Juan River for arsenic, cadmium, calcium, chromium, iron, lead, manganese, molybdenum, nitrate, selenium, sodium, sulfate, strontium, uranium, vanadium, lead-210, polonium-210, radium-226, thorium-230, ammonium, antimony, boron, chlorine, magnesium, nickel, phosphate, potassium, and zinc.

- Measuring electrical conductivity, temperature, pH, and alkalinity in the field at both surface and monitor well locations.

- Measuring dissolved oxygen and reduction/oxidation potential in the field at ground water monitoring locations.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AOM	Albuquerque Operations Manual
cm/s	centimeters per second
COC	chain of custody
DOC	dissolved organic carbon
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
ft	foot
ft/day	feet per day
FY	fiscal year
gal/min	gallons per minute
km	kilometer
L	liter
L/min	liters per minute
m	meters
mg/L	milligrams per liter
mi	mile
mL	milliliter
MSL	mean sea level
NRC	U.S. Nuclear Regulatory Commission
SOP	standard operating procedure
TAC	Technical Assistance Contractor
TDS	total dissolved solids
UMTRA	Uranium Mill Tailings Remedial Action
UMTRCA	Uranium Mill Tailings Radiation Control Act
USGS	U.S. Geological Survey
WSAP	water sampling and analysis plan

1.0 INTRODUCTION

A water sampling and analysis plan (WSAP) is required for each U.S. Department of Energy (DOE) Uranium Mill Tailings Remedial Action (UMTRA) Project site to provide a basis for ground water and surface water sampling at disposal and former processing sites. This WSAP identifies and justifies the sampling locations, analytical parameters, detection limits, and sampling frequency for the monitoring stations at the Shiprock, New Mexico, UMTRA Project site.

1.1 PURPOSE

The purposes of the water sampling at Shiprock for fiscal year (FY) 1994 are to 1) collect water quality data at new monitoring locations in order to build a defensible statistical data base, 2) monitor plume movement on the terrace and floodplain, and 3) monitor the impact of alluvial ground water discharge into the San Juan River. The third activity is important because the community of Shiprock withdraws water from the San Juan River directly across from the contaminated alluvial floodplain below the abandoned uranium mill tailings processing site.

1.2 SITE LOCATION

The Shiprock UMTRA Project site is on the Navajo reservation in northwestern New Mexico, Township 30 North, Range 18 West, Section 36 (Figure 1.1). The former mill site is situated on the south side of the town of Shiprock approximately 1 mile (mi) (1.6 kilometers [km]) from the town center and the intersection of U.S. Highways 64 and 666, major transportation routes in the region. The disposal cell rests on an alluvial terrace approximately 50 feet (ft) (15 meters [m]) above the floodplain on the southwest side of the San Juan River.

1.2.1 Land use

Land use is primarily agricultural on the floodplain of the San Juan River and pastoral grazing on the terraces and surrounding countryside. Livelihood in the rural portions of the Navajo reservation consists of sheep and cattle grazing on allotments allocated to each clan indigenous to the area. A residential neighborhood and fairgrounds are located approximately 0.3 mi (0.5 km) west of the site boundary.

1.2.2 Water resources

The San Juan River is the primary source of water in Shiprock and the surrounding area. Irrigation networks using river water support agriculture along the north side of the San Juan River. The community of Shiprock draws river water from two intake structures for use as drinking and irrigation water. One intake structure is 8 mi (13 km) upstream from Shiprock; the other is directly

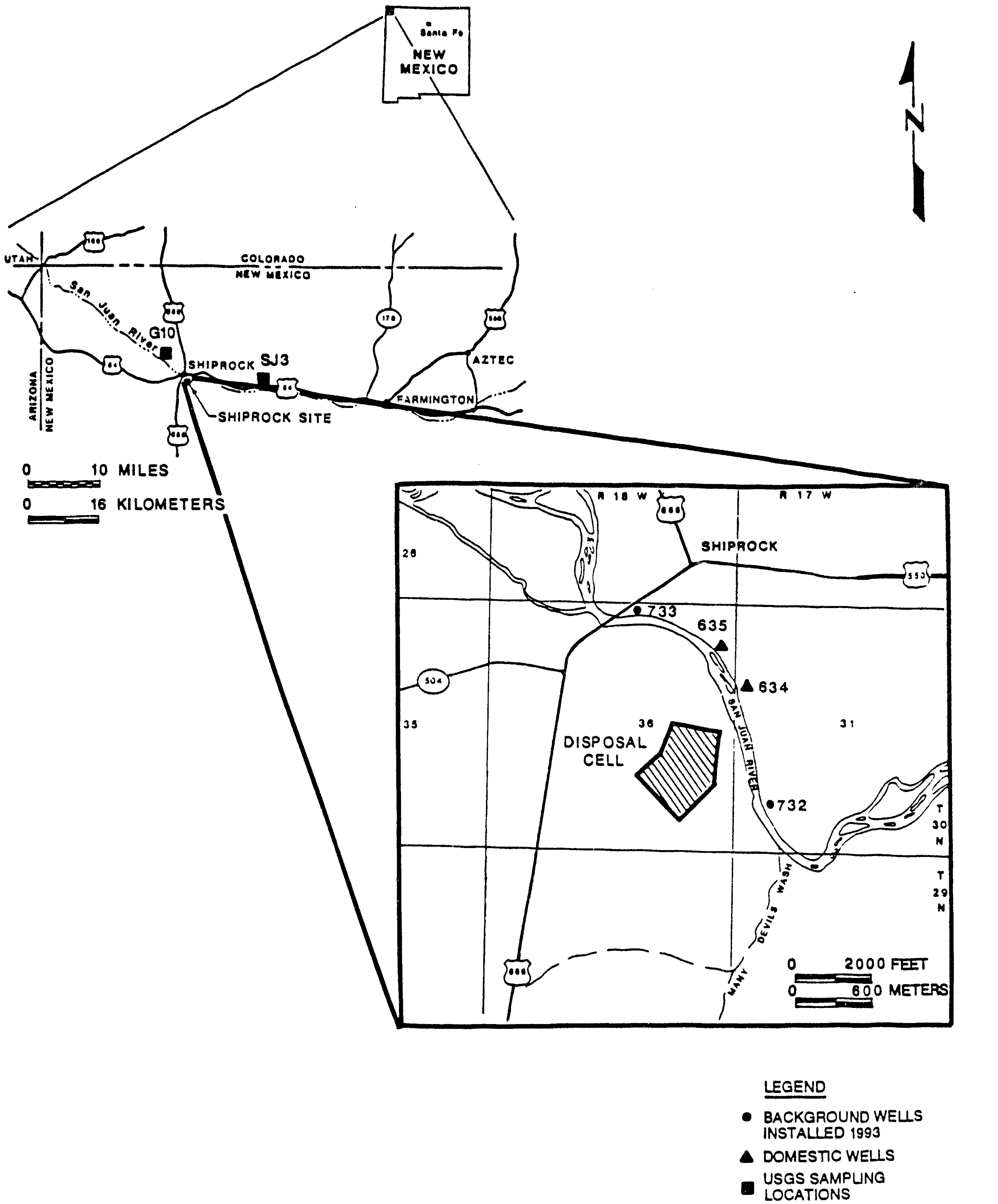


FIGURE 1.1
LOCATION MAP AND BACKGROUND WELL LOCATION FOR THE SHIPROCK, NEW MEXICO, SITE

across from the site on the north side of the San Juan River. The second intake structure is adjacent to monitor well 733 on the north side of the San Juan River (Figure 1.2). Each structure is used approximately 6 months of the year.

Water from an artesian well (monitor well 648 in Figure 1.2) is the primary source of water for livestock and gardens kept at residences located west of Bob Lee Wash. Residents occasionally drink this water during the summer, according to people filling containers at the well head.

1.3 SITE HISTORY

The Shiprock mill was constructed and operated from 1954 to 1963 by Kerr-McGee Oil Industries, Inc. From 1963 to 1968, the Vanadium Corporation of America and its successor, Foote Mineral Company, operated the mill. During the milling operations, the site was leased from the Navajo tribe. When the Foote Mineral Company's lease expired in 1973, full control of the site reverted to the Navajo Nation. The Navajo Engineering and Construction Authority is now situated on the remediated mill site adjacent to the uranium tailings containment cell.

The Shiprock mill processed approximately 1.5 million dry short tons (1.4 million tonnes) of ore from 1954 to 1968. The ore processed at Shiprock was mainly sandstone containing carnotite as the principal ore mineral. Ore was hauled to the mill from mines up to 200 mi (300 km) away, including ore concentrate from Monument Valley. Ore was first crushed and treated in a two-step sulfuric acid leaching process. Uranium and vanadium were recovered in two solvent extraction circuits; uranium in the first, vanadium in the second. The organic phases used in both circuits was a mixture of di(2-ethylhexyl) phosphoric acid and tributyl phosphate in a base of kerosene.

Tailings from the washing circuit were pumped to tailings ponds. Raffinate from the solvent extraction operation was disposed of in separate holding ponds and has subsequently evaporated and infiltrated into the terrace. The Shiprock mill produced approximately 3700 tons (3400 tonnes) of uranium oxide concentrate during its operating life. Vanadium concentrate was produced in 1955 and again from 1960 to 1968.

A containment cell was constructed in 1985 to accommodate rubble and waste from destruction of the former mill, tailings, windblown material, and vicinity property contamination. The site boundary is shown in Figure 1.2. The property is currently owned by the Navajo tribe, but institutional controls are in place.

Beginning in 1982 and continuing to the present time, ground water characterization studies have been carried out at the processing site by the following contractors: Ford, Bacon, & Davis, Inc. (FBDU, 1981); Geochemistry and Environmental Chemistry Research, Inc. (GECR, 1982); Dames and Moore (1982); Colorado State University (CSU, 1982); and the current DOE Technical

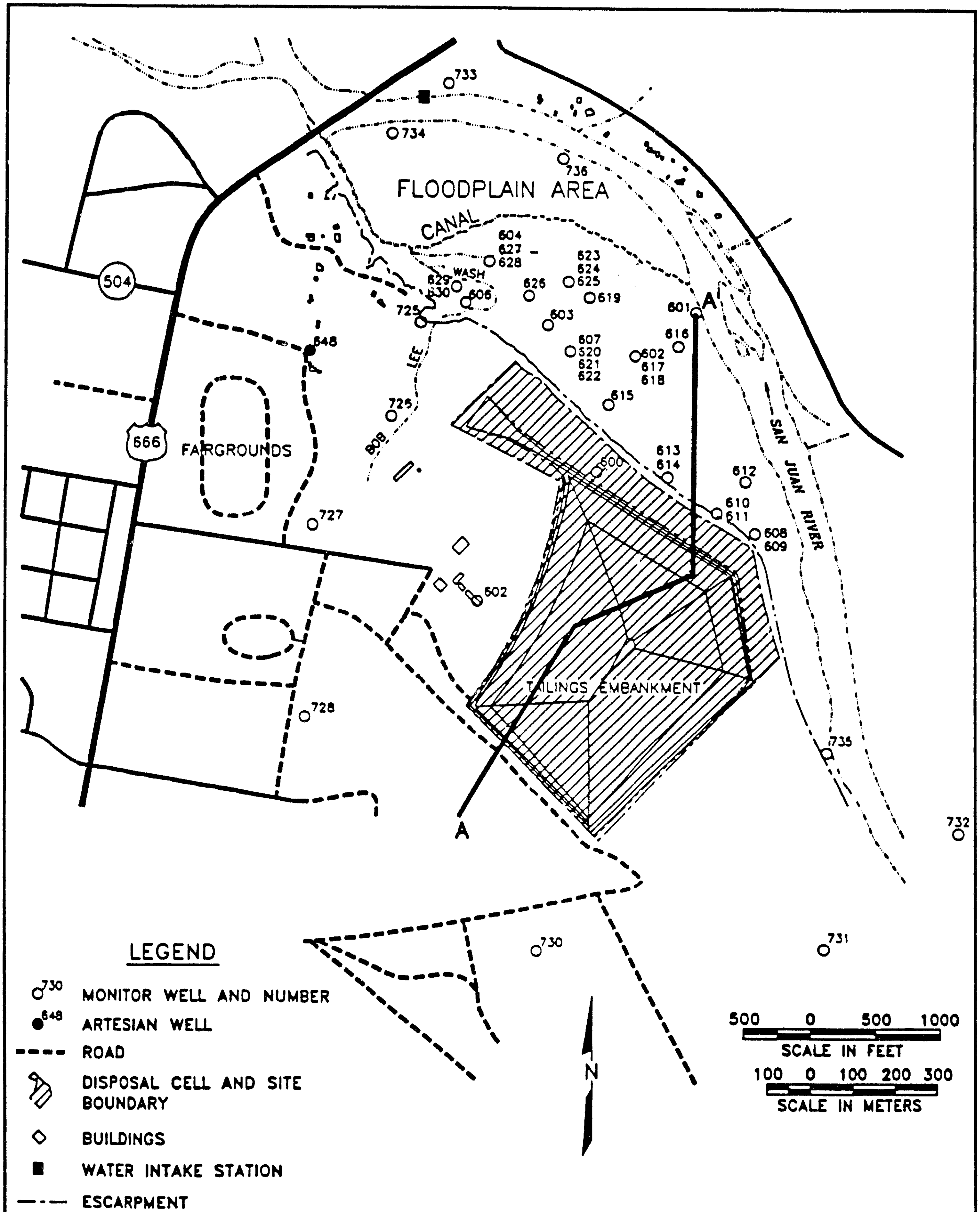


FIGURE 1.2

GROUND WATER SAMPLING LOCATIONS AT SHIPROCK, NEW MEXICO, SITE

Assistance Contractor (TAC), Jacobs Engineering Group Inc. These efforts have resulted in the installation and sampling of approximately 59 monitor wells on and around the site throughout the history of characterization.

1.4 SITE STATUS

Site cleanup was completed in 1985. Contaminated material has been placed in a cell on the terrace. The DOE has maintained responsibility for the site; as of December 1993, the U.S. Nuclear Regulatory Commission (NRC) had not licensed the site. Currently, ground water contamination is being monitored at select locations on the terrace and alluvial floodplain of the San Juan River.

1.5 SAMPLING PLAN SUMMARY

The Shiprock site is divided into two distinct hydrological areas: the terrace and the alluvial floodplain. The sampling plan summary will list locations for each area separately.

Terrace

The only sampling locations on the terrace are monitor wells that reach ground water in the shallow aquifer. These wells are grouped into two sets. One set is made up of wells drilled during the initial characterization and construction phase (600 and 602). The other set was drilled in 1993 (monitor wells 725 through 728, 730, and 731). The 1993 wells were drilled to determine background water quality and investigate the extent of the plume.

Water quality data from monitor wells 600 and 602 have been collected periodically since 1984, providing a historical data base. Water quality samples will be collected during FY1994 and analyzed for an abbreviated analyte list (Table 1.1). Constituents on this list will be used to monitor the plume in the vicinity of the tailings cell. These wells are currently the only monitoring points for the source of the plume.

Because monitor wells 725 through 731 were drilled in 1993, water quality samples have only been collected twice. Therefore, more sampling rounds are required from these wells to generate a statistical data base and to investigate trends in the water quality data over time. An extended analyte list has been requested to acquire a statistically viable data base.

Floodplain

Monitor wells installed during 1993 on the alluvial floodplain, monitor wells 732 through 736, will be sampled to generate a viable statistical water quality data base. Monitor wells 732 and 733 are especially important, because they serve as the only background ground water locations for the floodplain. The sampling plan calls for an extended analyte list to acquire a statistically viable data base.

Table 1.1 Analyte list, sampling frequency, and locations for the terrace and floodplain, Shiprock, New Mexico

Location	Analyte	Frequency
Terrace (SHP02) 725, 726, 727, 728, 730, 731 (monitor wells)	Sb, As, Cd, Ca, Mg, Ni, K, Na Cr, Fe, Pb, Mn, Mo, B, Hg, Se, Sr, U, Zn, Cl, SO_4, F, NH_4, NO_3, SiO_2, PO_4, TDS, DOC, U, V, Ra-226, Ra-228, Th-230	January 1994 Filtered samples
	Cd, Fe, Pb, U, V, Ra-226, Pb-210, Po-210, Th-230	Unfiltered samples
600 and 602 (monitor wells)	Sb, As, Cd, Ca, Mg, Ni, K, Na Cr, Fe, Pb, Mn, Mo, B, Hg, Se, Sr, U, Zn, Cl, SO_4, F, NH_4, NO_3, SiO_2, PO_4, TDS, DOC, U, V, Ra-226, Ra-228, Th-230	January 1994 Filtered samples
Floodplain (SHP01) 732, 733, 734, 735, 736 (monitor wells)	Sb, As, Cd, Ca, Mg, Ni, K, Na Cr, Fe, Pb, Mn, Mo, B, Hg, Se, Sr, U, Zn, Cl, SO_4, F, NH_4, NO_3, SiO_2, PO_4, TDS, DOC, U, V, Ra-226, Ra-228, Th-230	January 1994 Filtered samples
	Cd, Fe, Pb, U, V, Ra-226, Pb-210, Po-210, Th-230	Unfiltered samples
Seeps 425 and 426	U, TOC, SO_4, NO_3, Sr, Se	January 1994 Filtered and unfiltered samples
Surface locations 655, 656, 658, 659, 662	As, Cd, Ca, Cr, Fe, Pb, Mn, Mo, NO_3, Se, Na, SO_4, Sr, U, V, Pb-210, Po-210, Ra-226, Th-230, NH_4, Sb, B, Cl, Mg, Ni, PO_4, K, Zn,	January 1994 Unfiltered samples
San Juan River locations 546 through 555	As, Cd, Ca, Cr, Fe, Pb, Mn, Mo, NO_3, Se, Na, SO_4, Sr, U, V, Pb-210, Po-210, Ra-226, Th-230, NH_4, Sb, B, Cl, Mg, Ni, PO_4, K, Zn	January 1994 Unfiltered samples

Table 1.1 Analyte list, sampling frequency, and locations for the terrace and floodplain, Shiprock, New Mexico (Concluded)

Key	
Br - bromine	Ni - nickel
Cl - chloride	Pb - lead
F - fluorine	Sb - antimony
SO_4 - sulfate	Se - selenium
SiO_2 - silica	Sr - strontium
TDS - total dissolved solids	U - uranium
As - arsenic	V - vanadium
B - boron	Zn - zinc
Ba - barium	Hg - mercury
Ca - calcium	NH_4 - ammonium
Cd - cadmium	NO_3 - nitrate
Cr - chromium	PO_4 - phosphate
Fe - iron	DOC - dissolved organic carbon
Mg - magnesium	Ra-226 - radium-226
K - potassium	Ra-228 - radium-228
Mn - manganese	Pb-210 - lead-210
Mo - molybdenum	Po-210 - polonium-210
Na - sodium	Th-230 - thorium-230

Seeps 425 and 426, as well as all the other surface water locations, are shown in Figure 1.3. They will be sampled for an abbreviated analyte list (Table 1.1) to monitor the impact of ground water flow from the terrace to the floodplain. Analytes on this abbreviated list were chosen as indicator parameters to monitor the chemical contribution to the floodplain.

Surface locations 655, 656, 658, 659, and 662 (Figure 1.3) will be sampled in FY1994 for analytes shown in Table 1.1. These locations were identified during the 1993 risk assessment field study. They will provide information on the potential impact on wildlife and domestic animals if the animals should breach the fences surrounding the floodplain. An extended analyte list has been chosen to acquire additional data. These data will be used to check the validity and consistency of the first sampling round.

Water quality samples from the San Juan River (locations 546 through 555, Figure 1.3) will be collected to determine the potential impact on human health. Constituents are shown in Table 1.1. Water is withdrawn from the San Juan River for the drinking water supply at Shiprock, New Mexico. Therefore, the impact of ground water discharge from the floodplain into the San Juan River must be evaluated. An extensive analyte list is requested to monitor the potential threat to drinking water quality in the San Juan River.

Sufficient sampling has been conducted on the alluvial floodplain in the region of the plume to establish a statistically sound data base. Select locations should be sampled in FY1995 to monitor plume migration.

Static water level measurements will be taken in each well prior to purging. These data will be used to delineate the ground water flow direction and gradients. The rates of drawdown and recovery during well purging will be measured to qualitatively assess the yield of the aquifer on the terrace and the permeability of the floodplain deposits.

Section 5.0 contains decision criteria used for choosing sampling locations.

1.6 CHOICE OF CONSTITUENTS

The analyte list for the FY1994 WSAP were chosen for the following reasons:

- Because there are no source term data for the tailings at the Shiprock processing site, contaminants present in ground water downgradient from the processing site that are above background ground water quality, as determined in the 1993 baseline risk assessment (DOE, 1993), are included in the analyte list shown in Table 1.1. These contaminants include ammonium, antimony, arsenic, boron, cadmium, calcium, chloride, magnesium, manganese, nickel, nitrate, phosphate, potassium, selenium, sodium, strontium, sulfate, uranium, vanadium, and zinc.

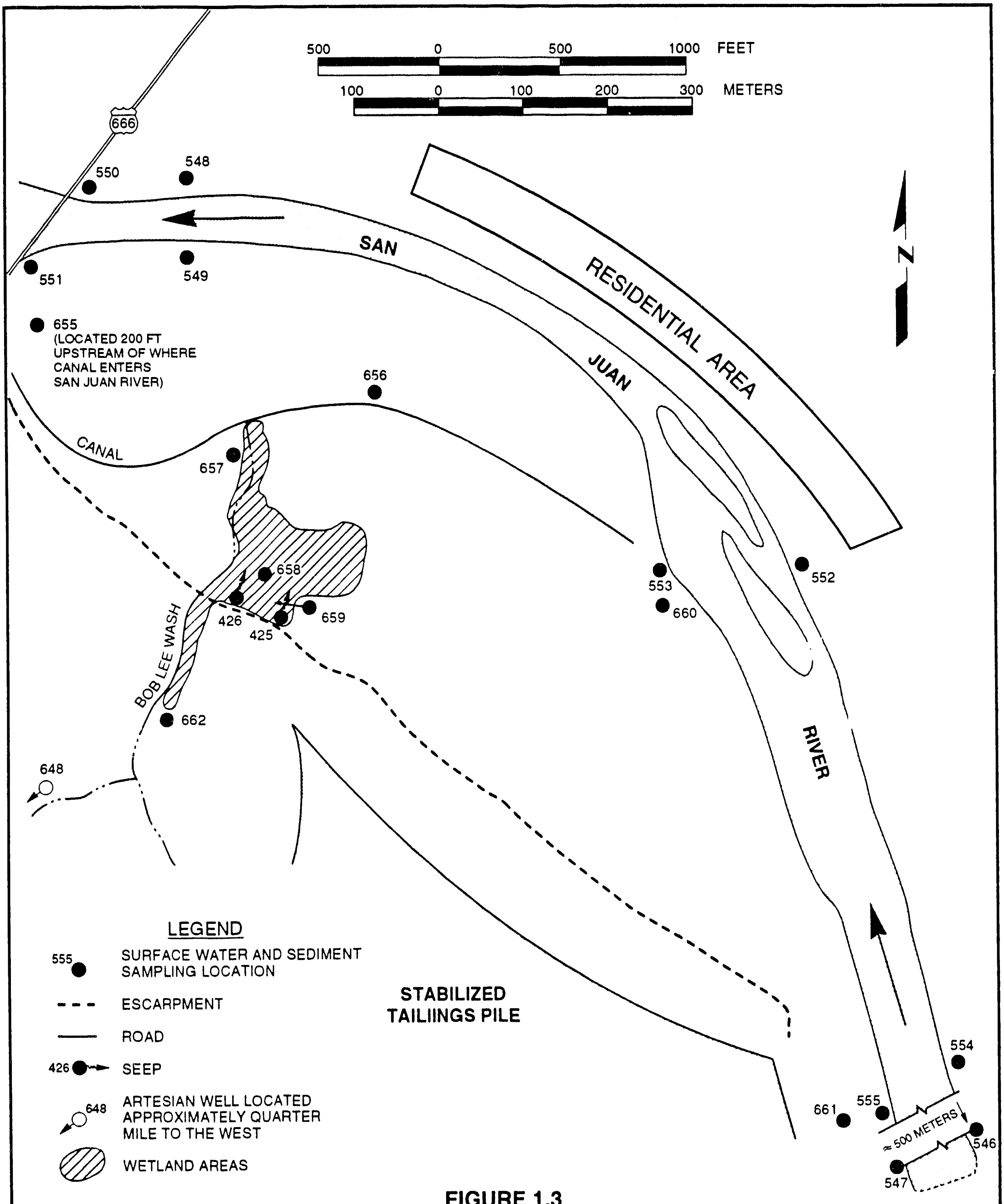


FIGURE 1.3
LOCATIONS OF FLOODPLAIN SURFACE WATER AND SEDIMENT SAMPLING STATIONS ADJACENT TO SHIPROCK TAILINGS SITE SHIPROCK, NEW MEXICO

- Contaminants associated with the milling process for which there is not a sufficient data base were also chosen. They include chromium, fluoride, iron, lead, mercury, molybdenum, and silica.

- Total dissolved solids (TDS) and dissolved organic carbon (DOC) were chosen because TDSs provide a check on the analysis of major ions and DOC provides insight on the potential mobility of weakly reduced elements such as manganese, iron, and selenium.

- Finally, radium-226 and -228, thorium-230, and polonium-210 were chosen because they provide information on the extent of contamination of radionuclides in ground water and surface water at the Shiprock site.

1.7 SUMMARY OF CHANGES TO LAST YEAR'S SAMPLING PLAN

Changes to the sampling strategy of FY1993 include adding monitor wells 600 and 602 on the terrace. These wells were not sampled during FY1993 but will be sampled during FY1994 to monitor the water quality of the plume on the terrace. Risk assessment locations (725, 726, 727, 728, 730, and 731) will continue to be sampled to generate a statistically valid data base and to monitor impact on human health and the environment.

2.0 SITE CHARACTERISTICS

2.1 PHYSIOGRAPHIC SETTING

The disposal cell is on an elevated river terrace southwest of the San Juan River (Figure 1.2). The site is relatively level, with natural elevation ranging from a high of approximately 4980 ft (1520 m) above mean sea level (MSL) along the southwestern edge of the property to a low of about 4950 ft (1510 m) along the top of a 50-ft (15-m) high, northwest-southeast trending escarpment. The escarpment separates the elevated terrace from the modern floodplain of the San Juan River. South of the site, the terrace continues gently upward for approximately 2500 ft (760 m), where it meets the weathered bedrock uplands.

The modern floodplain of the San Juan River is at the base of the escarpment north of the disposal cell. It begins approximately 1000 ft (300 m) upstream of the northeast corner of the site, widens to about 1500 ft (460 m), then pinches out against the bedrock escarpment at the bridge supporting U.S. Highway 666 over the San Juan River, approximately 2200 ft (670 m) downstream of the northwestern corner of the site.

Two arroyos are located east and west of the tailings site. Bob Lee Wash borders the western side of the site, and Many Devils Wash parallels Bob Lee Wash approximately 2500 ft (760 m) southeast of the site.

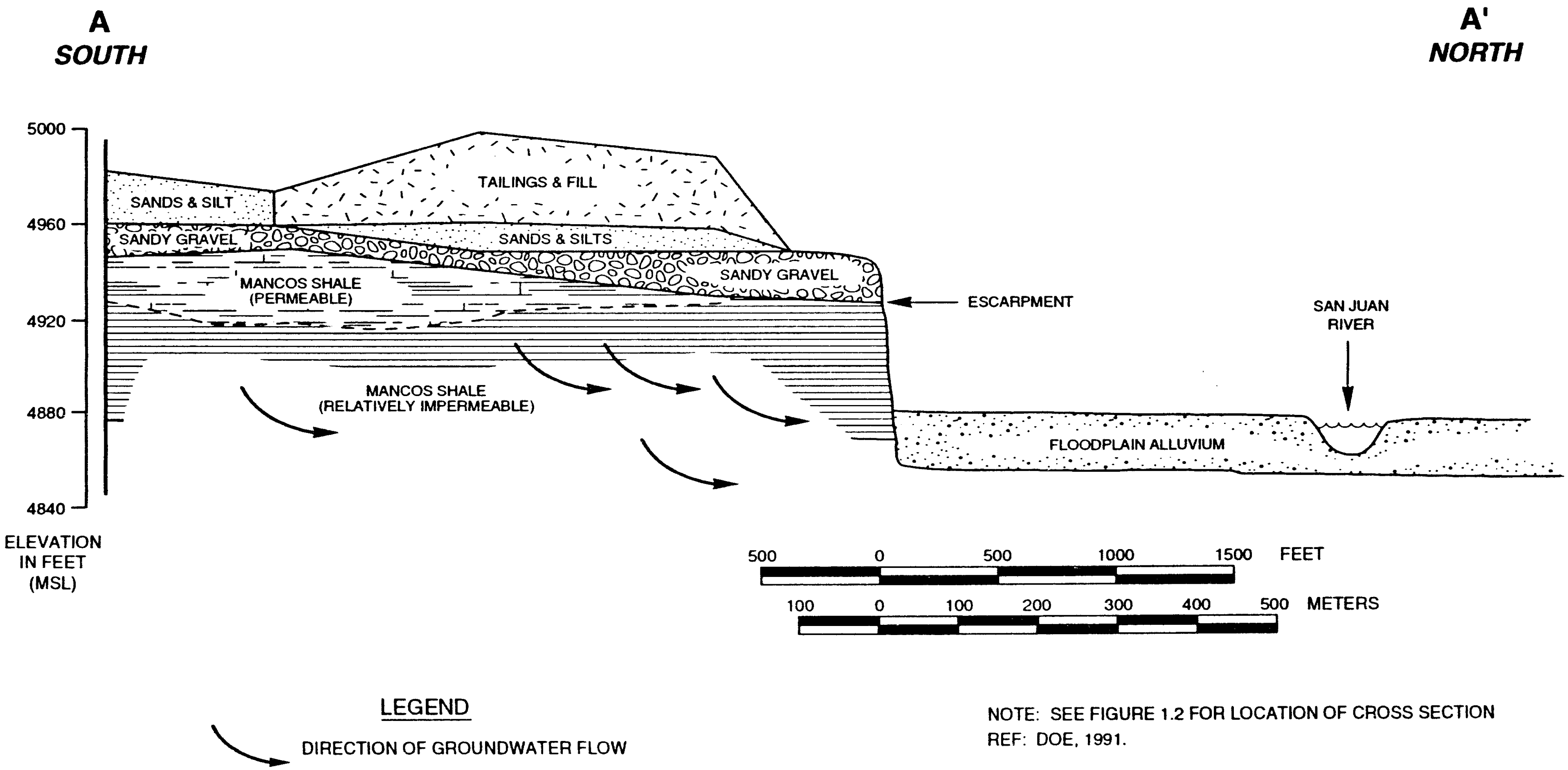
2.2 GEOLOGY

There are four hydrogeologic units relevant to the Shiprock site: the terrace alluvium; the floodplain alluvium; the Mancos Shale; and the deep, confined bedrock aquifers (Dakota Sandstone and Morrison Formation).

The disposal cell foundation rests on approximately 10 to 45 ft (3 to 13 m) of terrace alluvium. This alluvium consists of interbedded sands and silts with numerous lenses of gravel and cobbles (Figure 2.1).

The terrace deposit is underlain by Mancos Shale consisting of flat-lying beds of shales and sandy shales. In the Shiprock area, the Mancos Shale is approximately 1000 ft (300 m) thick (McLean and Johnson, 1987). The upper 10 to 30 ft (3 to 9 m) of the Mancos Shale is highly weathered, exhibiting fractures, fissility, and low strength. Below the highly weathered zone, the shale is more competent and relatively impermeable. Beneath the Mancos Shale are the Dakota Sandstone and the Morrison Formation.

North of the disposal cell is the floodplain of the San Juan River. The floodplain alluvium consists of unconsolidated, interbedded boulders, cobbles, gravels, sands, silts, and clays. The Mancos Shale underlies the floodplain alluvium at an average depth of approximately 15 ft (5 m). The alluvium within the



NOTE: SEE FIGURE 1.2 FOR LOCATION OF CROSS SECTION
REF: DOE, 1991.

FIGURE 2.1
CROSS SECTION A-A'
SHIPROCK, NEW MEXICO, SITE

MAC: SITE/SHP/WASP/REPX-SEC

SHPWASP

floodplain is separated from the terrace deposit beneath the disposal cell by a 50-ft (15-m) high vertical cliff. Mancos Shale is exposed in the lower two-thirds of the cliff.

2.3 HYDROLOGY

Terrace

Ground water below the disposal site on the terrace occurs in the alluvium; in the upper, weathered part of the Mancos Shale; and in the Morrison Formation. Some ground water may also occur in fractures or sandstone tongues in the unweathered Mancos Shale, but the extent of these occurrences has not been determined. The ground water in the alluvium and the upper part of the Mancos Shale is unconfined and constitutes the uppermost aquifer. Ground water in the Morrison Formation is confined. A flowing well (monitor well 648, Figure 1.2) near the site is reportedly completed in the Morrison Formation from approximately 1500 to 1900 ft (450 to 570 m) below land surface (McLean and Johnson, 1987). The free-flowing condition demonstrates that the piezometric surface in the Morrison Formation is higher than the water table in the alluvium or the upper part of the Mancos Shale. This higher head, combined with the low permeability of the unweathered Mancos Shale, will preclude movement of impacted water beneath the tailings pile into the deeper aquifers.

The terrace alluvium is recharged by approximately 9 inches (23 centimeters) of precipitation a year. In the vicinity of the mill site, the alluvium probably still contains water discharged from the former milling operations and tailings pile. The numerous lagoons active during the milling operations reportedly lost as much as 4.9 million gallons (19 million liters) per month. This amount of water in such a dry climate could have formed a considerable ground water mound perched on the Mancos Shale. Infiltrating seepage would move across the shale surface in all directions and infiltrate the upper, weathered zone of the shale. As the size of the mound diminished after the milling operations ceased, the movement of the perched ground water would be controlled by the topography of the Mancos Shale.

Ground water in the terrace system flows in a north to northwest direction. A series of paleochannels, remnants of the ancestral San Juan River, is thought to control ground water flow on the terrace.

Monitor wells installed to bracket the alluvial/bedrock interface and test pits that were excavated into the weathered shale indicate that only a relatively thin layer of water is perched on the bedrock. This perched ground water represents a very limited resource for future development.

The ground water in the alluvium also percolates down into the upper, fractured part of the Mancos Shale. Some of this water moves horizontally along bedding planes and vertical fractures and can be seen seeping from the Mancos along the escarpment face immediately north of the disposal site. It is also anticipated that ground water in the Mancos may flow toward the San Juan River, the local surface water base level in the region. This water would then move up out of the Mancos into the alluvium of the floodplain or directly into the river (Figure 2.1).

2.4 FLOODPLAIN HYDROLOGY

<u>Ground water</u>

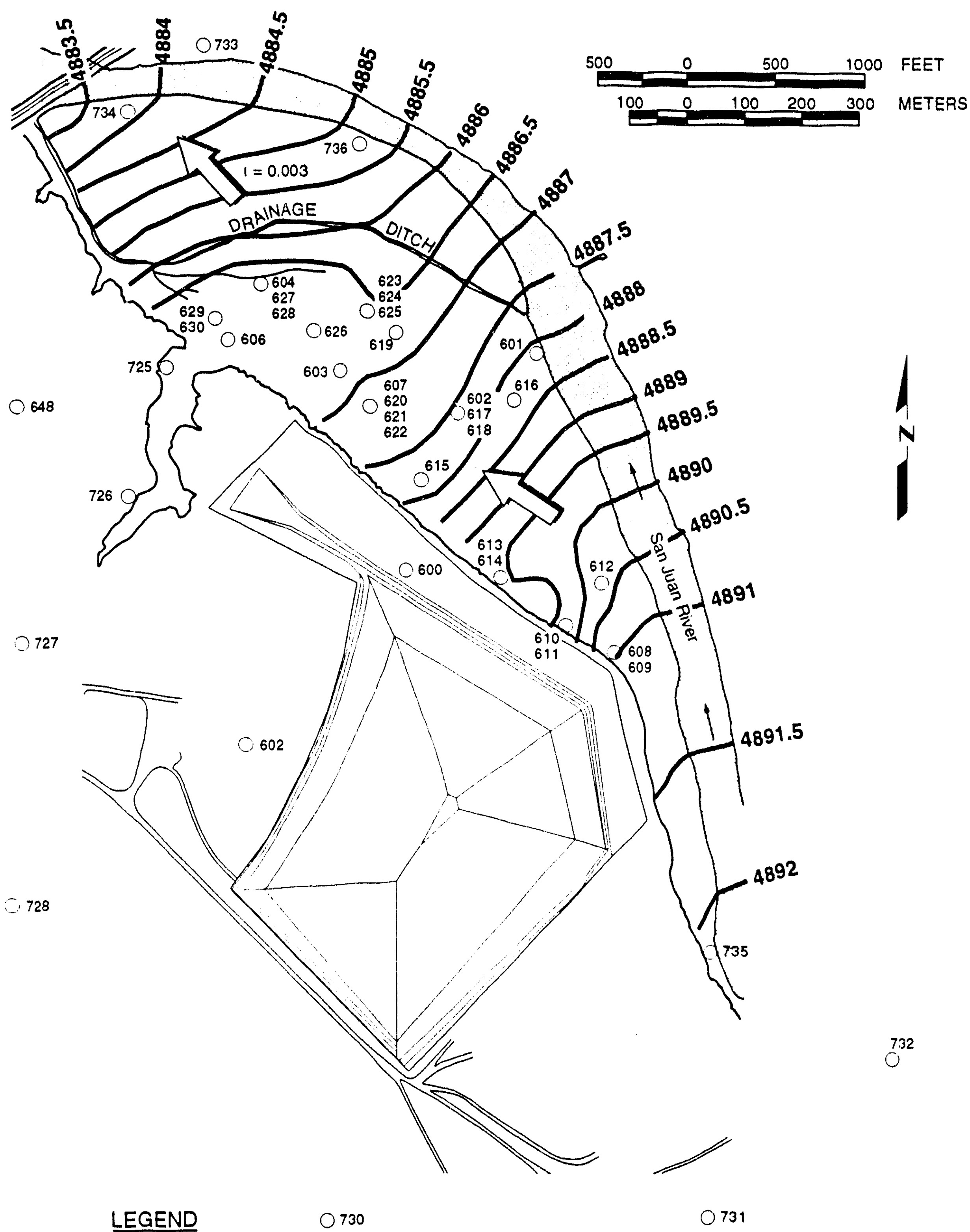
The floodplain alluvium contains a shallow ground water system with flow generally parallel to the San Juan River. Figure 2.2 shows water table elevations and the flow direction of ground water in the alluvial system. It is recharged primarily by water from the San Juan River that enters the floodplain at its upstream end, approximately 1000 ft (300 m) east of the tailings pile. Additional recharge comes from the flowing well at Bob Lee Wash and from the seeps along the escarpment. Figure 2.2 shows the ground water mound resulting from the flow down Bob Lee Wash. The floodplain alluvium is also the local discharge zone for the underlying Mancos Shale. The ground water in the floodplain then discharges back to the river along the downstream half of the floodplain.

During periods of high water level, some of the ground water flow in the floodplain enters a drainage ditch that separates the northwestern third of the floodplain (Figure 2.2). This portion of the ground water flow is then diverted into the ditch, which discharges to the river at the extreme northwestern end of the floodplain. During low water periods, however, the water table is beneath the bottom of the ditch.

The stratigraphy of the floodplain is extremely variable, both horizontally and vertically. The fluvial deposits are typical of floodplains in such environments; they vary from coarse gravel and cobbles found in high energy channels, to fine uniform sands indicative of point bars, to silty sediments typical of quiet backwater areas. This heterogeneity means that there is no one value of hydraulic conductivity representative of the entire floodplain.

Visual inspection of the sediments and comparisons with typical ranges described in the literature (Hunt, 1984) suggest that the hydraulic conductivity could vary by two orders of magnitude, from less than 5 feet per day (ft/day) (0.001 centimeters per second [cm/s]) to more than 300 ft/day (0.1 cm/s). Because the conductivity of these sediments partially controls the rate of discharge of impacted water to the San Juan River, an intermediate hydraulic conductivity typical of such sediments (approximately 30 ft/day [0.01 cm/s]) has been chosen.

The hydraulic gradient also varies across the floodplain, ranging from 0.0009 to 0.002 (DOE, 1988). A value of 0.003 was used to calculate the ground water velocity.



LEGEND

⇦	GROUND WATER FLOW DIRECTION
4887—	GROUND WATER ELEVATION APRIL 1993 (0.5' CONTOURS)
○ 730	MONITOR WELL
i = 0.003	GRADIENT

REF: BASED ON TOPOGRAPHY COMPILED BY KOOGLES & POULS ENGINEERING, INC.

FIGURE 2.2
GROUND WATER CONTOURS AND GRADIENT ON FLOODPLAIN
SHIPROCK, NEW MEXICO, SITE

MAC: SITE/SHP/WSAP/SHPASER2

Surface water

The San Juan River forms the eastern and northern boundaries of the floodplain north of and below the disposal cell. Surface runoff south and west of the site flows to the east and north into Bob Lee Wash. Bob Lee Wash also receives a constant discharge of approximately 60 gallons per minute (gal/min) (230 liters per minute [L/min]) from artesian well 648 located west of the wash (Figure 1.2). Discharge from this well flows down Bob Lee Wash into a swampy area on the floodplain (Figure 1.3). This water forms wetland areas near the bottom of Bob Lee Wash and on the floodplain (Figure 1.3). The water from the two seeps also contributes to the wetland. From the wetland, the water eventually flows across the floodplain and joins the San Juan River approximately 0.5 mi (0.8 km) northwest of the disposal cell.

Surface runoff east of the tailings pile either flows into a borrow area east of the site, then down the escarpment onto the floodplain, or it reaches Many Devils Wash, which discharges into the San Juan River approximately 0.5 mi (0.8 km) east of the cell.

In 1990, two seeps, locations 425 and 426 on Figure 1.3, were identified originating from the escarpment of Mancos Shale that rises from the San Juan River floodplain. Seep 425 is on the escarpment about 15 ft (5 m) above the floodplain near the northwest corner of the disposal cell. This seep is about 30 ft (9 m) long and consists of a series of drips under an overhanging indurated sand lens within the Mancos Shale. The flow rate from the seepage face was approximately 0.5 gal/min (2 L/min) in January 1991. The second seep (location 426, Figure 1.3) is immediately south of the point at which Bob Lee Wash enters the San Juan River floodplain. This seep is approximately 5 ft (2 m) above the floodplain and was flowing at a rate of about 1 gal/min (4 L/min) in January 1991. It is anticipated that the flow rate from these seeps will decrease during the dry months of the year.

2.5 WATER QUALITY

Water quality data have been collected since 1984 from most of the monitor wells and surface locations at Shiprock. At present, there are 8 monitor wells on the terrace, 34 monitor wells on the north and south floodplains, and 20 surface water locations that are currently monitored or have been sampled in the past. Water quality samples have also been collected from a well (648) west of Bob Lee Wash that is completed in the regional aquifer (Morrison Formation). Monitor well locations are shown in Figure 1.2, and surface sampling locations are shown in Figure 1.3.

2.5.1 Background water quality wells

Background water quality is defined as the quality of water if uranium milling activities had not taken place. Because there are two distinct shallow hydrologic systems at the Shiprock site, the terrace and the alluvial floodplain, it is necessary to determine background water quality for each hydrologic system.

Terrace

There are currently no background water quality data for the terrace.

Floodplain

Ground water in the floodplain below the terrace appears to have been pervasively degraded by milling activities. Therefore, data from this ground water cannot be used to determine background levels. Instead, background water quality data were taken from wells completed in the alluvial system north of the San Juan River. Wells used in the qualitative and quantitative background analysis are listed in Table 2.1. The locations of background wells are shown in Figure 1.1.

Table 2.1 Wells used to determine background water quality

Well number	Location	Screened interval (depth) ft	Screened interval (depth) m
Background wells installed 02/93			
732	Upstream from site on north side of San Juan River	7-17	2.1-5.2
733	North side of San Juan River	6.5-11.5	2.0-3.5
Domestic wells across from the floodplain			
634	In floodplain on north side of river	?-24[a]	?-7[a]
635	In floodplain on north side of river	?-12[a]	?-4[a]
USGS sampling locations			
SJ3	Well, upstream by Hogback	5-10	1.5-3
G10	Seep, downstream by Cudei	NA	NA

[a]Total well depth indicated, but screen length not known.

Monitor wells 732 and 733 (shown in Figure 1.2) and domestic wells 634 and 635 were used in the quantitative statistical background analysis. Water quality data from the U.S. Geological Survey (USGS) locations (SJ3 and G10) were used to qualitatively examine and compare ground water quality in the shallow alluvial system above and below Shiprock.

Background ground water can be generally described as a sulfate-bicarbonate, calcium-sodium type with slightly basic pH and TDSs ranging from 800 to 5000 milligrams per liter (mg/L). Background ground water quality data from the six locations shows some variability but have similar chemical compositions. Variability in water chemistry can be explained by 1) the distance of the well from the river (TDSs decrease away from the river), and 2) the depth of the well (TDSs appear to decrease with depth).

Generally, the San Juan River influences ground water quality adjacent to the river channel. The solute load of the river varies, depending upon which formation the river flows through, the amount of water each tributary contributes to flow, the evaporation rate, and the volume of flow in the river. Because of these effects, ground water chemistry is not homogeneous in the floodplain adjacent to the river. Sulfate/chloride ratio quotients in background wells in the alluvial aquifer range from 16 to 37, illustrating the variability in solute concentrations in this system.

2.5.2 Point-of-compliance wells

There are no point-of-compliance wells downgradient from the disposal cell on the terrace. The NRC has determined that the hydrogeology and ground water conditions in the vicinity of the cell have been adequately characterized and that the site "is over an aquifer not useful as a source of water for drinking or any other beneficial purpose because of its poor quality, limited areal extent, and low yield" (NRC, 1990; 1991). The NRC has also concluded that the infiltration through the cover and the stabilized tailings has been reduced to the maximum extent possible. In accordance with these findings, no ground water monitoring is proposed for the surveillance and monitoring program at Shiprock.

2.5.3 Plume delineation wells

Terrace

The plume on the terrace has not been delineated. Monitor wells 725, 726, 727, 728, 600, and 602 (Figure 1.2) define the plume chemically but do not delineate the areal extent.

Floodplain

Monitor wells 608, 609, 610, 611, 613, 614, and 615 (Figure 1.2) were used to define the center of the plume on the floodplain. Contamination on the floodplain is pervasive, so the areal extent of the plume is defined by the boundary of the floodplain. Monitor wells 601, 612, 734, and 736 (Figure 1.2) are located on the boundary of the floodplain and the San Juan River. They monitor the quality of ground water discharging into the San Juan River.

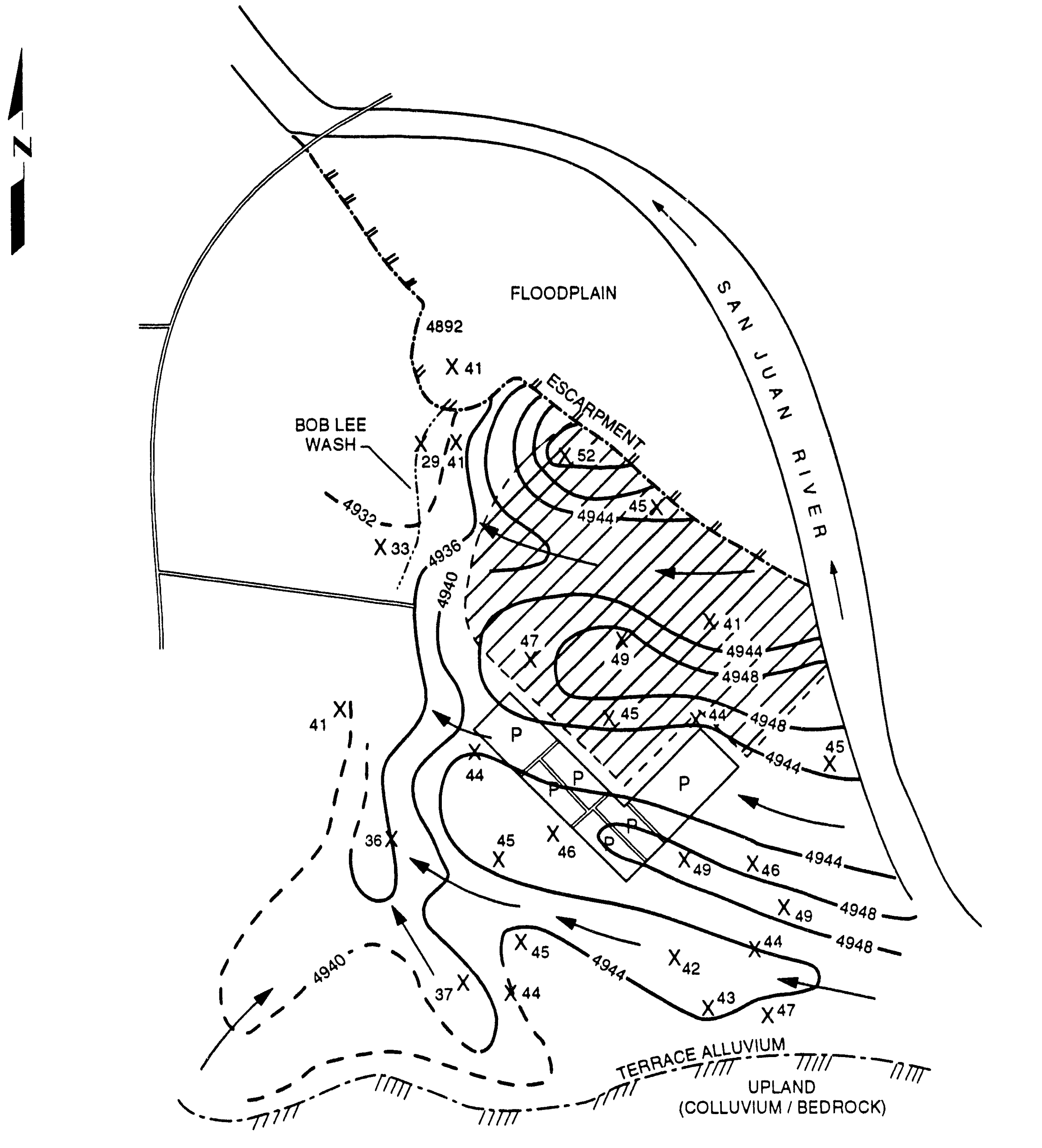
2.5.4 Surface water sampling locations

Surface water sampling locations include the San Juan River upstream and downstream from the site (locations 546 through 555), ponded water on the floodplain (locations 658 and 659), the ditch on the floodplain (locations 655 and 656), and location 662 from the bottom of Bob Lee Wash. Surface locations are shown in Figure 1.3.

2.6 SITE CONCEPTUAL MODEL

The tailings have been contained in a disposal cell on the terrace. The cell rests on terrace alluvium, which rests on the Mancos Shale (cross section A-A', Figure 2.1). Information from drilling logs implies the presence of paleochannels incised into the upper Mancos and filled with alluvial material (Figure 2.3). These channels may provide preferential flow paths for ground water in the alluvial/weathered Mancos system. Ground water generally flows to the north. Ground water in the upper, weathered Mancos system is probably restricted to preferential flow in tensional fractures that formed as a response to erosional unloading of the Mancos Shale. These fractures form complementary sets revealing their vertical geometry on the face of the escarpment above the alluvial floodplain.

Ground water from the alluvial/Mancos system discharges into the floodplain at two seep locations (425 and 426, Figure 1.3). Elevated nitrate and uranium concentrations in ground water sampled from the seeps imply impact from milling activities. The contribution from the alluvial terrace, along with residual contamination from discharges onto the floodplain during the milling process, are probably responsible for the contamination of ground water in the floodplain. Generally, contaminated ground water in the floodplain aquifer flows from the southeast to northwest (Figure 2.2), eventually discharging to the San Juan River.



4892 — BEDROCK SURFACE CONTOUR

41 X — BEDROCK ELEVATION IN BORING (+4900)

← SWALE ON BEDROCK SURFACE

FORMER TAILINGS PILES AND MILL SITE

P — FORMER RAFFINATE POND

500 0 1000 FEET

150 0 300 METERS

FIGURE 2.3
BEDROCK SURFACE CONTOURS ON TERRACE
SHIPROCK, NEW MEXICO, SITE

3.0 DATA COLLECTION OBJECTIVES

3.1 REGULATORY REQUIREMENTS

U.S. Environmental Protection Agency (EPA) regulations defining the health and environmental protection standards for UMTRA Project sites are in 40 CFR Part 192. Other regulations regarding ground water and surface water monitoring are included in the *Federal Register* (52 FR 36000 [1987]). The *Federal Register* document is a published proposed regulation. Although these regulations are in proposed and draft form, the authorizing statute for the UMTRA Project, the *Uranium Mill Tailings Radiation Control Act* (UMTRCA) of 1978 (42 USC §7901 *et seq.*), allows the 1987 proposed published regulations to be used until the regulations are published in final form.

The regulatory requirements for ground water and surface water sampling specify the following needs:

- To protect human health and the environment.
- To protect water.
- To determine background water quality.
- To identify the presence, constituent concentrations, and movement of any plumes.
- To monitor disposal cell performance.

3.2 LONG-TERM PERFORMANCE MONITORING

There is no plan to conduct long-term monitoring of cell performance at the Shiprock site.

3.3 SITE CHARACTERIZATION

Although the initial site characterization was completed in 1986, additional information in the form of water quality data and other field measurements contribute to the site conceptual model. Ground water quality on the terrace will be monitored for temporal concentration trends with the existing array of wells downgradient from the disposal cell (monitor wells 600, 602, 725, 726, 727, and 728).

Ground water monitoring on the alluvial floodplain will focus on sampling locations at the San Juan River-floodplain boundary to monitor the contribution of ground water discharge to the San Juan River. This network comprises monitor wells 601, 734, and 736 and surface water locations 546 through 555.

Background ground water locations 732 and 733 will be sampled to provide additional background ground water quality data in the floodplain aquifer.

3.4 RISK ASSESSMENT CONSIDERATIONS

The sampling plan for FY1994 is primarily driven by the assessment of risk. Data derived from San Juan River sampling locations 546 through 555; surface sampling locations 655, 656, 658, 659, and 662; and ground water sampling locations 732 and 734 will be used to monitor potential impact on wildlife and human health on the floodplain.

Monitoring of ground water on the terrace (monitor wells 600, 602, 725, 726, 727, and 728) will provide information on the chemical character of the plume. Monitor locations 731 on the terrace and 735 on the eastern portion of the floodplain will provide information on the extent of contamination.

Background wells 732 and 733 in the floodplain will be sampled to generate a viable statistical water quality data base for geochemical baseline purposes.

3.5 OTHER CONSIDERATIONS

Three stations for measuring river water levels will be developed during FY1994 to aid in ground water flux calculations to the San Juan River.

4.0 DATA QUALITY OBJECTIVES

4.1 ANALYTICAL METHODS, HOLDING TIMES, AND DETECTION LIMITS

Analytical methods, holding times, and detection limits are described in the *Statement of Work for UMTRA Project TAC General Inorganic and Radiochemical Analyses* (TAC, 1993). Tables 4.1 and 4.2 list the analytical methods, holding times, and detection limits approved and used by the UMTRA Project.

4.2 SAMPLE FILTRATION

Water samples shall be filtered in accordance with standard operating procedure (SOP) 16.2.1, "Sample Collection, Preservation, and Shipment of Water Samples" (JEG, n.d.). Analyte bottles that are filtered with a 0.45 micrometer filter at the request of the site hydrologist and or site geochemist shall be labeled as follows:

A-1, M-2, Pb-210, Po-210, Ra-226, Ra-228, Th-230, and GA/GB.

Filtered analyte bottles that shall be collected at the Shiprock site are A-1, M-2, Ra-226, Ra-228, and GA/GB.

4.3 SAMPLE PRESERVATION AND SHIPMENT

The TAC *Albuquerque Operations Manual* (AOM) contains SOPs for TAC UMTRA Project activities. The SOPs referenced below are from the AOM (JEG, n.d.).

Soil, water, and other environmental samples shall be preserved in accordance with the following procedures:

14.5.1 "Procedures for Handling and Shipping of Geotechnical Samples"

16.2.10 "Packaging, Shipping, and Custody of Environmental Samples"

All samples shall be shipped through a chain-of-custody (COC) procedure as described in Section 4.4.

4.4 CHAIN-OF-CUSTODY PROCEDURES

COC procedures are covered in two AOM SOPs (JEG, n.d.). SOP 16.2.10, "Packaging, Shipping, and Custody of Environmental Samples," covers COC for water samples and other environmental samples such as biological samples. SOP 14.5.1, "Procedures for Handling and Shipping of Geotechnical Samples," covers COC for rock and soil samples. These SOPs shall be adhered to when samples covered in this WSAP are collected and shipped. Any deviation from

Table 4.1 Sample preservation techniques and holding times

Bottle ID	Parameter(s)	Volume/container	Preservation	Holding time[a]
A-1	Br, Cl, F, SO_4, SiO_2	1 L plastic	None, 4°C	28 days
	TDS	Above	None, 4°C	7 days
M-2	Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mg, K, Mn, Mo, Na, Ni, Pb, Sb Se, Sn, Sr, Tl, U, V, Zn	500 mL plastic	HNO_3, pH <2	180 days
	Hg	Above	HNO_3, pH <2	28 days
N-1	NH_4, NO_3, TKN PO_4	500 mL plastic	H_2SO_4, pH <2 4°C	28 days
CN	Total CN	1 L plastic	NaOH, pH > 12 4°C	14 days
S	Sulfide	2x500 mL plastic	NaOH, pH > 9 Zn acetate 4°C	7 days
DOC	DOC	500 mL amber glass	H_2SO_4, pH < 2 4°C	28 days
TOC	TOC	500 mL amber glass	H_2SO_4, pH < 2 4°C	28 days
Ra-226	Ra-226	2x1 L plastic	HNO_3, pH < 2	180 days
Ra-228	Ra-228	2x1 L plastic	HNO_3, pH < 2	180 days
Pb-210	Pb-210	1 L plastic	HNO_3, pH < 2	180 days
Po-210	Po-210	1 L plastic	HNO_3, pH < 2	180 days
Th-230	Th-230	1 L plastic	HNO_3, pH < 2	180 days
GA/B	Gross alpha, Gross beta, U	500 mL plastic	HNO_3, pH < 2	180 days

[a]Holding time is calculated from the date and time the sample was taken.
mL - milliliter
L - liter

Table 4.1 Sample preservation techniques and holding times (Concluded)

Key

Br - bromine
Cl - chloride
F - fluorine
SO_4 - sulfate
SiO_2 - silica
TDS - total dissolved solids
Ag - silver
Al - aluminum
As - arsenic
B - boron
Ba - barium
Be - beryllium
Ca - calcium
Cd - cadmium
Co - cobalt
Cr - chromium
Cu - copper
Fe - iron
Mg - magnesium
K - potassium
Mn - manganese
Mo - molybdenum
Na - sodium
Ni - nickel
Pb - lead
Sb - antimony
Se - selenium
Sn - tin
Sr - strontium
Tl - thallium
U - uranium
V - vanadium
Zn - zinc
Hg - mercury
NH_4 - ammonium
NO_3 - nitrate
TKN - total Kjeldahl nitrogen
PO_4 - phosphate
Total CN - cyanide
DOC - dissolved organic carbon
TOC - total organic carbon
Ra-226 - radium-226
Ra-228 - radium-228
Pb-210 - lead-210
Po-210 - polonium-210
Th-230 - thorium-230
HNO_3 - bicarbonate
H_2SO_4 - sulfuric acid
NaOH - sodium hydroxide

Table 4.2 UMTRA Project detection limits and techniques

Parameter	Contract-required detection limit (mg/L)	Technique(s)[a]
Aluminum	0.05	ICP-AES
Ammonium as NH_4	0.10	Colorimetric
Antimony	0.003	GFAA, ICP-MS
Arsenic	0.005	GFAA, $NaBH_4$
Barium	0.10	ICP-AES
Beryllium	0.005	ICP-AES
Boron	0.10	ICP-AES
Bromide	0.10	IC
Cadmium	0.001	GFAA, ICP-MS
Calcium	0.50	ICP-AES
Chloride	0.50	IC, colorimetric
Chromium	0.01	ICP-AES
Cobalt	0.05	ICP-AES
Copper	0.02	ICP-AES
DOC	1.0	UV promoted oxidation-IR
Total cyanide	0.010	Colorimetric
Fluoride	0.10	ISE
Iron	0.03	ICP-AES
Lead	0.003	GFAA, ICP-MS
Magnesium	0.10	ICP-AES
Manganese	0.01	ICP-AES
Mercury	0.0002	CVAA
Molybdenum	0.01	ICP-AES
Nickel	0.04	ICP-AES
Nitrate as NO_3	1.0	Colorimetric, IC
Potassium	0.10	ICP-AES, FAA
Selenium	0.005	GFAA, $NaBH_4$
Silver	0.01	ICP-AES
Silica as SiO_2	0.10	ICP-AES
Sodium	1.0	ICP-AES, FAA
Strontium	0.01	ICP-AES
Sulfate	1.0	IC
Sulfide	1.0	Titrimetric, colorimetric
Thallium	0.005	GFAA, ICP-MS
Tin	0.05	ICP-AES, GFAA, ICP-MS
TDS	10	Gravimetric

Table 4.2 UMTRA Project detection limits and techniques (Concluded)

Parameter	Contract-required detection limit (mg/L)	Technique(s)[a]
Total Kjeldahl nitrogen	1.0	Colorimetric
Total organic carbon (TOC)	1.0	UV promoted oxidation-IR
Total phosphorus as PO_4	0.10	Colorimetric
Uranium	0.001	ICP-MS, fluorometric
Vanadium	0.01	ICP-AES
Zinc	0.05	ICP-AES

Parameter	Lower limit of detection (pCi/L)	Technique(s)[a]
Gross alpha	1.0	PC
Gross beta	0.5	PC
Pb-210	1.5	LSc, PC
Po-210	1.0	AS, PC
Ra-226	1.0	AS, ASc
Ra-228	1.0	PC
Th-230	1.0	AS

[a]Where more than one technique is specified, the first technique listed is preferred. Technique acronyms and abbreviations are defined below.

AS	Alpha spectrometry
ASc	Alpha scintillation
CVAA	Cold vapor atomic absorption spectroscopy
FAA	Flame atomic absorption spectroscopy
GFAA	Graphite furnace atomic absorption spectroscopy
IC	Ion chromatography
ICP-AES	Inductively coupled plasma-atomic emission spectroscopy
ICP-MS	Inductively coupled plasma-mass spectrometry
IR	Infrared
ISE	Ion specific electrode
LSc	Liquid scintillation
$NaBH_4$	Sodium borohydride reduction atomic absorption spectroscopy
PC	Proportional counter
UV	Ultraviolet

these procedures shall be approved by the site manager and site hydrologist or geochemist and shall be justified in a written memorandum.

4.5 SAMPLE COLLECTION METHODS AND SEQUENCE

Water samples and other environmental samples shall be collected according to the following TAC SOPs (JEG, n.d.):

14.5.1 Procedures for Handling and Shipping of Geotechnical Samples

16.1.6 Soil-Water Sampler Installation and Sample Collection

16.1.10 Field Measurements for Temperature, Conductivity, pH, Alkalinity, and Total Acid

16.1.11 Sample Collection for Organic Substances

16.1.13 Field Determination of Oxidation/Reduction Potential in Water Samples

16.1.14 Field Determination of Dissolved Oxygen in Water Samples

16.1.16 Alternate Method for Determination of Dissolved Oxygen

16.1.21 Measurement of Water Turbidity

16.2.1 Sample Collection, Preservation, and Shipment of Water Samples

16.2.2 Water Sampling for Tritium Analysis

16.2.4 Sampling Radon in Water

16.2.5 Monitor Well Sampling With an Electric Submersible Pump

16.2.6 Monitor Well Sampling With a Bladder Pump

16.2.7 Monitor Well Sampling With a Peristaltic Pump

16.2.8 Quality Control Samples for Water Sampling

16.2.9 Monitor Well Sampling With a Bailer

16.3.1 Inventory and Documentation of Damage and Repair of UMTRA Project Wells

5.0 SAMPLING PLAN

This section addresses sampling needs for FY1994. Table 1.1 lists the constituents and frequency of sampling for FY1994.

5.1 SAMPLING LOCATIONS

5.1.1 Monitor wells

Terrace

Eight monitor wells will be sampled on the terrace during FY1994: monitor wells 600, 602, 725, 726, 727, 728, 730, and 731. Monitor wells 725, 726, 727, 728, 730, and 731 were installed and only sampled twice during 1993; additional samples are required to develop an adequate statistical data base. Monitor wells 600 and 602 provide water quality information on the center of the plume adjacent to the cell. These wells monitor changes in water quality following completion of the cell. These wells will also monitor water quality for risk assessment purposes.

Floodplain

Background ground water monitor wells 732 and 733, on the north side of the San Juan River, will be sampled during FY1994. These wells were installed and sampled twice in 1993. Consequently, a more representative statistical data base for background ground water quality is required.

Ground water monitoring locations 734 and 736 near the downstream end of the floodplain will be sampled to monitor concentrations of constituents at the regions where ground water discharges into the San Juan River. Monitor well 735 will also be sampled to monitor ground water quality in the eastern portion of the floodplain and to increase the statistical ground water quality data base. Water quality from these wells will be used to calculate the ground water/San Juan River risk assessment mixing model.

5.1.2 Surface water stations

Surface water stations along the San Juan River will be sampled to comply with the risk assessment goals. Human and nonhuman health effects of ground water from the floodplain discharging into the San Juan River and affecting the water quality is of primary concern. San Juan surface locations 546 through 555 will be sampled in FY1994 for these risk assessment purposes.

Other surface locations will be sampled to monitor the impact of water quality on wildlife. These sampling locations include seeps 425 and 426 and surface locations 655, 656, 658, 659, and 662 on the floodplain and in Bob Lee Wash.

5.2 CONSTITUENT SELECTION

The constituents to be analyzed from surface and ground water locations are discussed below.

5.2.1 Field parameters

Electrical conductivity, temperature, pH, and alkalinity will be measured at both surface and monitor well locations. In addition, dissolved oxygen and reduction/oxidation potential will be measured at ground water sampling locations.

5.2.2 Laboratory analysis

Table 1.1 contains a list of analytes and sampling locations for 1994.

5.3 WATER LEVEL MEASUREMENTS

Static ground water level measurements will be taken in each well prior to purging. These data will be used to delineate the ground water flow direction and gradients.

The rates of drawdown and recovery during well purging will be measured to qualitatively assess the yield of the aquifer on the terrace and the permeability of the floodplain deposits. Water levels will be measured periodically during purging (at 1- to 5-minute intervals, depending on the rate of drawdown) and periodically as water levels recover after purging.

5.4 SAMPLING FREQUENCY

There will be one sampling round during January 1994. This sampling event will coincide with the low flow of the San Juan River and winter withdrawal of drinking water from the San Juan River across from the alluvial floodplain (SHP01).

5.5 DATA INTERPRETATION METHODS

Ground water downgradient from the cell on the terrace and representative plume wells on the floodplain will be monitored for temporal changes in ground water quality. Surface water on the floodplain will be monitored to assess impact to the environment and to accumulate a viable statistical data base. Monitoring involves routine water quality data collection, data evaluation, data interpretation, and possible resampling. The TAC UMTRA geochemist and statistician will perform geochemical and statistical analysis on the data to test for significant trends in ground water quality. The TAC risk assessment team and the TAC statistician will analyze data from the baseline risk assessment monitor wells to test for significant trends in water quality that may affect the quality and health of human and nonhuman life.

5.6 RESPONSE TO ANOMALOUS DATA

Anomalous data will be handled according to AOM SOPs 16.3.2, "Validation of Chemical Analysis Data," and 16.3.3, "Data Management" (JEG, n.d.).

6.0 LIST OF CONTRIBUTORS

The following individuals contributed to the preparation of this report.

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D. Tarbox	Hydrogeologist
R. Papusch, R. Saar, D. Tarbox	Technical review
L. Keith, C. Slosberg	Text processing
B. Harvey	Graphic design
A. Cree, D. Thalley	Technical editing

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FEDERAL REGISTER

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UNITED STATES CODE

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END

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