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ATTACHMENT 3

GROUNDWATER HYDROLOGY REPORT

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1.0 INTRODUCTION

The U.S. Environmental Protection Agency (EPA) has established health and environmental protection regulations to correct and prevent groundwater contamination resulting from processing activities at inactive uranium milling sites (40 CFR 192). According to the Uranium Mill Tailings Radiation Control Act of 1978, (UMTRCA) (48 CFR 590), the U.S. Department of Energy (DOE) is responsible for assessing the inactive uranium processing sites. The DOE has determined this assessment shall include information on hydrogeologic site characterization. The water resources protection strategy that describes how the proposed action will comply with the EPA groundwater protection standards is presented in Attachment 4. Site characterization activities discussed in this section include:

- Characterization of the hydrogeologic environment, including hydrostratigraphy, groundwater occurrence, aquifer parameters, and areas of recharge and discharge.

- Characterization of existing groundwater quality by comparison with background water quality and the maximum concentration limits (MCLs) of the proposed EPA groundwater protection standards.

- Definition of physical and chemical characteristics of the potential contaminant source, including concentration and leachability of the source in relation to migration in groundwater and hydraulically connected surface water.

- Description of local water resources, including current and future use and value, availability, and alternative supplies.

The EPA promulgated final groundwater protection standards for the disposal and cleanup of the inactive uranium processing sites under the UMTRCA on January 5, 1983. However, the groundwater provisions of the regulations (40 CFR 192.20(a)(2)-(3)) were remanded to the EPA by the U.S. Tenth Circuit Court of Appeals on September 3, 1985. The EPA issued proposed groundwater protection standards (52 CFR 36000) on September 24, 1987. Table 1.1 summarizes these groundwater standards.

Under the UMTRCA, the DOE must comply with the proposed groundwater protection standards until the final standards are promulgated. Consequently, remedial action at the Durango site would not affect the selection or implementation of reasonable groundwater restoration methods that may be necessary when the final standards are promulgated. The DOE has characterized conditions at the Durango uranium mill tailings site and the disposal site in Bodo Canyon. When the final EPA standards are promulgated, the DOE will again evaluate the groundwater protection requirements and determine the need for institutional or other controls to ensure compliance with the regulations. Evaluation of aquifer restoration and control of existing groundwater contamination at the Durango processing site will be addressed under a separate process in accordance with the National Environmental Policy Act (NEPA).

Table 1.1 Proposed EPA groundwater protection standards

Hazardous constituent with proposed EPA MCLs	Concentration (mg/l)
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Molybdenum	0.10
Nitrate (NO_3)	44
Selenium	0.01
Silver	0.05
Radium-226 and -228 (pCi/l)	5
Uranium-234 and -238 (pCi/l)	30
Net gross alpha (pCi/l)	15
Benzene (Cyclohexatriene)	0.005
Carbontetrachloride	0.005
p-Dichlorobenzene (Benzene, 1, 4 di-)	0.075
1-Dichloroethylene (Ethene, 1, 1 di-)	0.007
Endrin	0.0002
Ethylene dichloride	0.005
Lindane	0.004
Methoxychlor	0.100
Methylchloroform	0.200
Toxaphene	0.0055
2,4-D (Dichlorophenoxyacetic acid)	0.100
2,4,5-TP (Trichlorophenoxyprophoric acid)	0.010
Trichloroethylene	0.005
Vinyl chloride	0.002

Appendix I and Appendix IX inorganic hazardous constituents and elements in hazardous constituent compounds that must not exceed background water quality[a]

Antimony	--
Aluminum (aluminum phosphide)	--
Beryllium and compounds	--
Cobalt	--
Copper	--
Cyanides (soluble salts and complexes)	--
Fluoride (carbon oxyfluoride)	--
Nickel and compounds	--
Strontium (strontium sulfide)	--
Sulfide	--
Thallium and compounds	--
Tin	--
Vanadic acid, ammonium salt	--
Vanadium (vanadium pentoxide)	--
Zinc (zinc phosphide)	--

[a]See Appendix IX, 40 CFR 264.

2.0 HYDROGEOLOGIC SITE CHARACTERIZATION SUMMARY

2.1 PROCESSING SITE

The following is a summary of the information gathered to characterize the hydrogeologic conditions at the Durango site.

- Several studies have been performed at the Durango processing site, such as reconnaissance-level investigations of the geology and hydrology and an economic evaluation of the tailings, soil and groundwater geochemical investigations, characterization of the tailings pore water by suction lysimeter sampling and batch leach testing of tailings samples, engineering evaluation of the tailings, radiological characterization of soils, and hydrogeological characterization of the site and surrounding area including determining aquifer parameters and local groundwater quality.

- The Durango processing site is underlain by up to 60 feet of alluvium, colluvium, and man-made fill, which comprise the uppermost aquifer. The alluvium and colluvium gravels were derived from glacial outwash and recent fluvial processes.

- The alluvial aquifer is recharged by infiltration of precipitation and surface runoff and by inflow from Lightner Creek and the Animas River during periods of high flow. In the former tailings pile area groundwater flows to the southeast, subparallel to the Animas River. Discharge from the alluvial aquifer is to the Animas River. In the former tailings area, the depth to groundwater in the alluvium generally ranges from eight to 11 feet. In the raffinate ponds area alluvial saturation occurs locally.

- The alluvial aquifer beneath the former tailings area exhibited hydraulic conductivities ranging from 20 feet/day (ft/day) (0.007 centimeters per second (cm/s)) to 380 ft/day (0.1 cm/s) (BFEC, 1983). In the former tailings area, the underlying Mancos Shale has a reported hydraulic conductivity ranging from 6 ft/day (0.002 cm/s) to 30 ft/day (0.01 cm/s). Hydraulic conductivities from 0.006 ft/day (2×10^{-6} cm/s) to 23 ft/day (0.008 cm/s) in the Menefee Sandstone, and 0.1 ft/day (4×10^{-5} cm/s) to 2 ft/day (7×10^{-4} cm/s) in the Point Lookout Sandstone were also reported for the raffinate ponds area. A hydraulic conductivity ranging from 0.2 ft/day (7×10^{-5} cm/s) to 7 ft/day (3×10^{-3} cm/s) was determined for the fault zone in the raffinate pond area.

- Background water quality in the alluvial aquifer at the raffinate ponds area is a mixed magnesium/sodium sulfate type with total dissolved solids (TDS) ranging from 1670 to 4910 milligrams per liter (mg/l) and pH ranging from 6.6 to 8.3. Analyses of groundwater samples indicate that maximum background concentrations or activities of cadmium, chromium, molybdenum, net gross alpha, and selenium have exceeded the proposed EPA MCLs.

- From the 1880s to 1930, a lead smelter operated at the Durango site. During this period, the smelting operation created a slag pile stretching from the base of Smelter Mountain to the Animas River. In 1941, the United States Vanadium Corporation began reprocessing vanadium tailings for the recovery of uranium for the Manhattan Project. During the 14-year period of operations, about 1.6 million tons of ore were processed. Ore averaging 0.29 percent uranium oxide and 1.6 percent vanadium oxide was trucked to the Durango mill from all parts of the Uravan Mineral Belt. All active milling operations at the site ended in March 1963. Remediation of all tailings materials and excavated raffinate ponds materials began in 1987. These materials were transported to the Durango disposal cell in Bodo Canyon. The disposal cell was completed in 1991.

- Inorganic hazardous constituents with MCLs with concentrations or activities that exceeded the laboratory method detection limits in tailings pore water from monitor wells samples include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Elements listed individually or included in compounds that are listed in Appendix I of 40 CFR 192 or in Appendix IX of 40 CFR 264 with concentrations that exceed the laboratory method detection limit include ammonium, beryllium, cobalt, copper, fluoride, nickel, vanadium, and zinc.

- Elements of hazardous compounds were also analyzed. The four elements of hazardous compounds and their respective hazardous compounds are the following: 1) aluminum as aluminum phosphide; 2) ammonium as a salt of vanadic acid; 3) fluoride as carbon oxyfluoride; and 4) strontium as strontium sulfide. None of these four compounds would exist under normal geochemical conditions expected of uranium mill tailings. Therefore, these hazardous compounds and their respective elements are not considered as hazardous constituents at the Durango processing site or the Bodo Canyon disposal site.

- Mean or median observed concentrations or activities of arsenic, cadmium, molybdenum, radium-226 and -228, selenium, and uranium in tailings pore water exceeded the MCLs. In addition, the mean or median concentrations of five hazardous constituents (cobalt, copper, fluoride, vanadium, and zinc) that do not have MCLs exceeded the statistical maximum of background groundwater quality at the processing site.

- Hazardous constituents with MCLs with concentrations or activities that exceeded the laboratory method detection limits in alluvial monitor wells at the former tailings area include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded the laboratory method detection limits include antimony, copper, fluoride, nickel, sulfide, thallium, tin, vanadium, and zinc.

- Maximum observed concentrations or activities of seven hazardous constituents equalled or exceeded proposed EPA MCLs in the alluvial aquifer downgradient of the former tailings pile area. These constituents include arsenic, cadmium, chromium, molybdenum, net gross alpha, selenium, and uranium. Of the six hazardous constituents with concentrations that exceed the MCLs in groundwater downgradient of the former tailings pile area, selenium and uranium are the only hazardous constituents that exhibit statistical evidence of groundwater contamination related to uranium processing.

- There is statistical evidence that vanadium and zinc are groundwater contaminants related to uranium processing in the former tailings pile area. There is no statistical evidence that copper and fluoride are groundwater contaminants.

- Hazardous constituents with MCLs with concentrations or activities that exceeded the laboratory method detection limits in Menefee and Point Lookout Formation monitor wells at the former raffinate ponds area include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded the laboratory method detection limits include antimony, copper, fluoride, nickel, sulfide, thallium, tin, vanadium, and zinc.

- Maximum observed concentrations or activities of eight hazardous constituents equalled or exceeded proposed EPA MCLs in the Menefee and Point Lookout Formation groundwater system downgradient of the former raffinate ponds area. These constituents include arsenic, cadmium, chromium, lead, molybdenum, net gross alpha, selenium, and uranium. The statistical maximum for background groundwater quality was exceeded for vanadium.

- For the eight hazardous constituents with concentrations that exceed the MCLs in the bedrock groundwater system downgradient of the former raffinate ponds area, there is no statistical evidence that they are groundwater contaminants related to uranium processing. There is no statistical evidence that vanadium is a groundwater contaminant related to uranium processing in the former raffinate ponds area.

- The major water supply for the city of Durango comes from gallery collection systems located in the floodplain alluvium of the Animas River upgradient of the tailings piles and raffinate pond areas. The closest downgradient private wells are approximately two miles south and southeast of the site. It is highly unlikely that private wells will be affected by groundwater contamination west of the Animas River.

2.2 DISPOSAL SITE

The following is a summary of the information gathered to characterize the Bodo Canyon disposal site.

- o Previous studies have been performed at the disposal site, such as reconnaissance-level investigations of the geology and hydrology, geotechnical evaluation of the surface and subsoils, geochemical properties of the subsoils, and hydrogeological characterization of the site and surrounding area including determining the hydraulic parameters of the aquifer and local groundwater quality.

- o From information obtained during the field investigations, the Bodo Canyon disposal site is underlain by (in descending order) unconsolidated Quaternary alluvial and colluvial deposits, the Cliff House Sandstone, the Menefee Formation (siltstones, shales, and coal seams), and the Point Lookout Sandstone.

- o Shallow groundwater occurs within the alluvium, colluvium, and weathered shale, at depths that range seasonally from approximately 20 to 50 feet below the surface. The thickest areas of the alluvial deposits occur along a subsurface paleochannel feature carved into the underlying bedrock. Groundwater flow in the alluvium is generally toward the northeast along the axis of the Bodo Canyon basin most of the year. Borehole and monitor well data suggest that a large area of the alluvium is not saturated most of the time. The large area of Bodo Basin covered by the disposal cell and the change in recharge to the alluvium caused by the disposal cell indicate that desaturation of the alluvium beneath the disposal cell will likely occur under steady-state conditions.

- o Groundwater also occurs in the Cliff House Sandstone and Menefee Formation beneath the disposal site. The Cliff House and Menefee Formations are considered to be one hydrogeologic unit. This groundwater is recharged in the areas of outcrop along the northern edge of Bodo Canyon and to a lesser extent from the overlying alluvium. The groundwater in these two formations flows downdip to the south-southeast.

- o The transmissivity of the alluvium ranges from 150 square feet per day (ft^2/day) to 280 ft^2/day. The hydraulic conductivity ranges from 6×10^{-4} ft/day (7.4×10^{-3} cm/s) to 40 ft/day (0.014 cm/s). Storage coefficient values ranged from 5×10^{-4} to 0.19.

- o In the alluvium, the horizontal hydraulic gradient of the northeastern flow direction is 0.003 ft/ft. The average linear groundwater is 0.7 ft/year, using an average hydraulic conductivity of 0.13 ft/day and an assumed effective porosity of 25 percent.

- o In 1989, an aquifer test was conducted in a monitor well completed in the Menefee Formation. The resulting calculated transmissivity is 7.5 ft^2/day and the calculated hydraulic conductivity is 0.3 ft/day (1.1×10^{-4} cm/s). The geometric mean of all field

hydraulic conductivities in the Menefee and Cliff House Formations is 0.07 ft/day.

- In the Cliff House and Menefee Formations, the average horizontal hydraulic gradient is 0.19 ft/ft. The average linear groundwater velocity of flow in the Cliff House and Menefee Formations is 33 ft/year to the southeast, using an average hydraulic conductivity of 0.07 ft/day and an assumed effective porosity of 15 percent.

- Background groundwater quality data for the alluvium indicate that concentrations or activities of radium-226 and -228, molybdenum, and net gross alpha concentrations have equalled or exceeded proposed EPA MCLs.

- Selenium concentrations that exceed MCLs in alluvial monitor wells downgradient of the disposal cell are related to surface discharges of water from the retention pond DS-1 or the seep that emanated from the cell before a toe drain was constructed. However, there is no statistical evidence of groundwater contamination for any hazardous constituent in the alluvium groundwater.

- Background groundwater quality data for the Cliff House and Menefee Formations indicate that hazardous constituents with MCLs with concentrations that exceeded the laboratory method detection limits include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded laboratory method detection limits include antimony, beryllium, cobalt, copper, nickel, sulfide, thallium, tin, vanadium, and zinc.

- Maximum observed concentrations of five hazardous constituents equalled or exceeded proposed EPA MCLs in the Cliff House and Menefee Formations. These constituents include cadmium, chromium, molybdenum, net gross alpha, radium-226 and -228, and selenium. However, the lower end of the 98 percent confidence interval concentrations of these constituents does not exceed MCLs.

- Quartz, amorphous silica, and feldspar are the dominant minerals in the sub-disposal cell sediments. The geochemistry of these sediments is controlled by the minor and trace minerals. Up to 35 weight percent of the sediments are clay-sized particles, while only 10 to 20 volume percent are clay minerals. The dominant clays are of the non-reactive type and these sediments have relatively low cation exchange capacities and low attenuation capacity for most hazardous constituents that are dissolved in groundwater as cations.

- Sub-disposal cell sediments contain greater than one weight percent acid-soluble iron and very little acid-soluble manganese. These values indicate that the sediments are totally oxidized and will have little attenuation capacity for those hazardous constituents that precipitate under reducing conditions. However, selenium, arsenic, molybdenum, and vanadium should be attenuated through

surface complexation with iron oxide minerals in the Bodo Canyon sediments.

- Batch leach tests were conducted using core samples of the unconsollidated sediments and pore fluids collected from a toe drain that was installed in the disposal cell. The attenuation batch experiments indicate that the subsurface sediments beneath the Bodo Canyon disposal cell will adsorb all of the vanadium, a majority of the arsenic in solution, a lesser amount of selenium and uranium, and a small amount of the molybdenum. These sediments will also adsorb those constituents that are present as cations.

- EPA Method 3050 analyses and batch leach tests on the disposal cell scarified liner material indicate that hazardous constituents are not being concentrated in the disposal cell liner.

- An investigation of the physiochemical conditions in the monitor wells completed within the Cliff House and Menefee Formations indicates that the groundwater becomes slightly more reducing as one moves from the upgradient to the downgradient side of the disposal cell. The moderately reducing conditions in the Cliff House Formation downgradient of the disposal site have the potential to precipitate the hazardous constituents arsenic, molybdenum, selenium, and uranium.

- Within a one-mile radius of the Bodo Canyon disposal site there are four registered wells. These wells are used for stock watering and domestic purposes. They are completed upgradient and cross gradient of the disposal cell in the Cliff House and Menefee Formations. These wells will not be affected by the disposal cell in Bodo Canyon.

3.0 GROUNDWATER INVESTIGATIONS

3.1 PROCESSING SITE

The Durango processing site consisted of two distinct areas, the former tailings pile area and the raffinate ponds area. The former tailings pile area is bounded on the east by the Animas River, on the north by Lightner Creek, and on the southwest by Smelter Mountain. The former raffinate ponds area is bounded on the north and east by the Animas River, on the west by Smelter Mountain, and on the south by an intermittent drainage. The former ponds were covered with the surrounding soil after deactivation of the processing site.

3.1.1 Previous investigations

Previous site-specific studies that addressed groundwater at the Durango processing site were initiated in 1976. Engineering assessments by Ford, Bacon and Davis Utah Inc. (FBDU) were conducted in 1976 and in 1980 (FBDU, 1981). This engineering assessment included the preparation of topographic maps, the drilling of borings for radiometric measurements sufficient to determine areas and volumes of tailings and radiation exposures of individuals and nearby populations, the investigation of site hydrology and meteorology, and the evaluation of alternative corrective actions. FBDU also performed an economic evaluation of the tailings to determine the value of uranium given various extraction techniques. The borings identified in the FBDU (1981) report were not used in subsurface characterization due to the unavailability of well logs and quality assurance documentation.

Markos and Bush (1983) characterized the geochemical composition of the background soils at the site and the tailings material, the extent of contamination in surface soils and surface water resulting from the former milling activities and tailings, and the mechanisms of transport of contaminants away from the site. In 1982, Bendix Field Engineering Corporation (BFEC) investigated groundwater occurrence, aquifer characteristics, groundwater quality, and surface water quality at the Durango processing site; 14 monitor wells were installed around the tailings piles (Figure 3.1) and 11 monitor wells in the raffinate ponds area (Figure 3.1). The hydrogeologic units in which these monitor wells were completed include the shallow alluvium and shale or sandstone bedrock.

DOE investigations

Additional hydrogeologic field data were collected by the DOE from 1985 to 1990 to further characterize the lithology, groundwater elevations and hydraulic gradients, aquifer properties, and groundwater quality at the processing site. The DOE has utilized selected BFEC monitor wells in upgradient, cross-gradient, and downgradient locations from the tailings site and raffinate ponds area in site

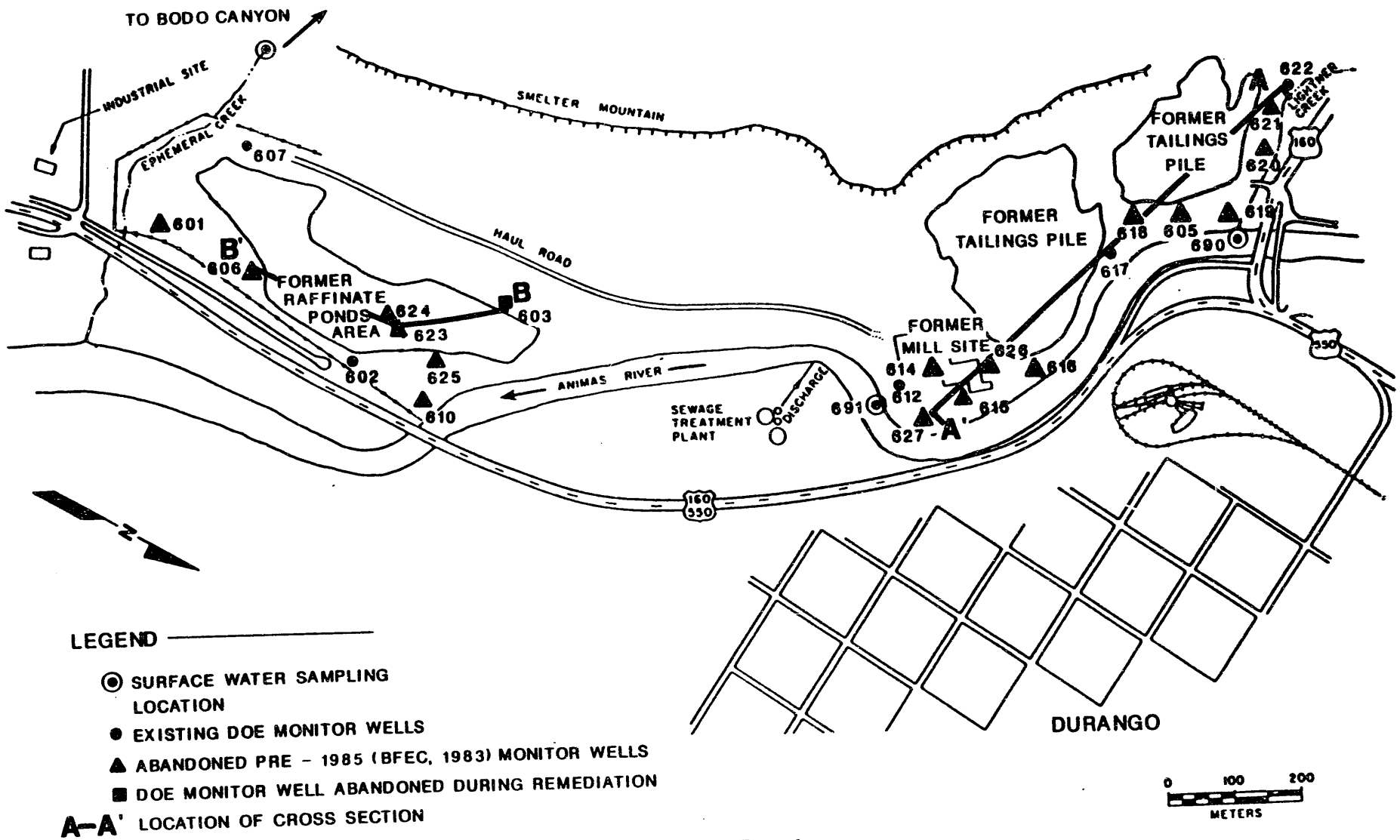


FIGURE 3.1
MONITOR WELLS, SURFACE WATER SAMPLING LOCATIONS, AND CROSS SECTION LOCATIONS
DURANGO PROCESSING SITE, COLORADO

characterization programs. In 1984, the DOE renamed the BFEC monitor wells with three digit numbers beginning with "6". The DOE well locations are shown in Figure 3.1. In 1985, the DOE began sampling six of the monitor wells in the former tailings piles area and raffinate ponds area on a quarterly basis. Monitor well construction information regarding all DOE monitor wells shown on Figure 3.1 is listed in Table 3.1.

In 1987, eight lysimeters were installed in the tailings piles to various depths below the surface of the tailings. The lysimeters were sampled and the water was analysed to characterize hazardous constituents related to uranium processing present in the tailings pore water.

Groundwater elevations have been measured, and directions of groundwater flow and hydraulic gradients have been determined. Aquifer tests have been conducted to determine aquifer properties. Groundwater samples have been collected from monitor wells and analyzed to determine groundwater quality and to establish the degree and extent of contamination caused by activities related to the uranium processing at the site.

The hydrogeology of the Durango area has been discussed in a Draft Site Characterization Report for the processing site (DOE, 1984b), a Final Environmental Impact Statement (DOE, 1986b), a Remedial Action Plan (DOE, 1986a), and a U.S. Bureau of Reclamation (USBR) Characterization Report (USBR, 1990). Selected information from all of these documents was used in writing this report. The Durango processing site hydrogeology is presented in the following sections. Water quality data presented in this document are a result of past and on-going DOE sampling programs.

3.1.2 Geology and hydrostratigraphy

The former tailings pile area is underlain by up to 60 feet of alluvium, colluvium, and man-made fill. The Quaternary alluvium and colluvium gravels were derived from glacial outwash and recent fluvial processes. The alluvium and colluvium generally consist of angular fragments of sandstone and minor shale in a matrix of sand and sandy clay and locally may contain minor amounts of groundwater. In addition, the vicinity of the former mill site is underlain by up to 35 feet of man-made fill, including up to 25 feet of vitreous smelter slag materials. This material contains little or no groundwater. The alluvium is underlain by Cretaceous-age Mancos Shale bedrock, which contains minor interbeds of argillaceous and arenaceous limestone, and argillaceous sandstone (BFEC, 1983; Markos and Bush, 1983). A geologic cross section of the tailings area is shown in Figure 3.2. The cross section location is shown in Figure 3.1.

Up to 47 feet of alluvium, colluvium, and man-made fill materials overlie the bedrock surface in the raffinate ponds area. These unconsolidated materials in the raffinate ponds area are underlain by both the Point Lookout Sandstone and the Menefee

TABLE 3.1 - MONITOR WELL INFORMATION, FORMER TAILINGS PILE AREA AND FORMER RAFFINATE PITS AREA, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
REPORT DATE: 12/19/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT) *	CASING STICKUP (FT)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT) *	CASING + DIAMETER (INCHES)	SCREEN * BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0604	47930.8	50374.4	6516.60	62.50	0.30	6516.90	-	-	-	-	D	NR
0605	48984.4	49387.8	6491.50	20.00	-	-	-	-	-	-	D	SM
0606	48984.4	49387.8	6491.50	20.00	-	-	-	-	-	-	N	NR
0607	48984.4	49387.8	6491.50	20.00	-	-	-	-	-	-	N	NR
0612	47902.1	50611.0	6491.80	55.00	0.30	6492.10	50.30	4.000	30.00	20.0	D	SH
0614	48083.4	50503.1	6507.90	65.00	0.90	6508.80	62.90	4.000	44.00	10.0	D	SH
0615	48334.3	50519.2	6495.20	50.00	0.40	6495.60	48.40	4.000	33.00	15.0	D	GP
0616	48494.9	50489.2	6473.50	21.00	0.90	6474.40	17.90	4.000	11.00	5.0	D	GP
0617	48713.7	49746.6	6496.20	35.00	1.20	6497.40	33.20	4.000	14.00	15.0	D	SH
0618	48867.7	49470.5	6489.80	22.00	1.10	6490.90	21.60	4.000	10.50	10.0	D	SH
0619	49082.4	49494.7	6474.50	15.00	0.40	6474.90	14.40	4.000	6.00	4.0	D	SH
0620	49257.1	48906.4	6489.00	15.00	1.50	6490.50	14.50	4.000	6.50	5.0	D	GP
0621	49256.2	48741.9	6492.50	20.00	1.10	6493.60	20.10	4.000	8.00	6.0	D	GP
0622	49308.0	48656.9	6492.90	20.00	1.00	6493.90	20.00	4.000	9.00	5.0	U	GP
0626	48300.9	50407.9	6498.60	-	0.50	6499.10	48.50	4.000	26.00	20.0	D	GP
0627	48154.2	50640.2	6495.90	51.00	1.00	6496.90	46.00	4.000	33.00	10.0	D	SM

* DEPTH GIVEN IN FEET BELOW GROUND SURFACE

+ CASING DIAMETER = INSIDE DIAMETER

FORMATION OF COMPLETION CODE:
NR - NO RECOVERY OF DATA FOR CLASSIFYING
SM - SILTY SAND OR SILTY GRAVELLY SAND
SH - SHALE
GP - GRAVEL OR SANDY GRAVEL, POORLY GRADED

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
N - UNKNOWN
U - UPGRADIENT

DATA FILE: M:\DART\DUR01\MWI10000.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

TABLE 3.1 (cont.) - MONITOR WELL INFORMATION, FORMER TAILINGS PILE AREA AND FORMER RAFFINATE PITS AREA, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
REPORT DATE: 12/19/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT) *	CASING STICKUP (FT)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT) *	CASING + DIAMETER (INCHES)	SCREEN * BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0601	44262.6	52032.6	6492.80	52.00	0.30	6493.10	82.30	4.000	51.00	30.0	C	SH
0602	45157.6	52084.8	6484.40	162.00	0.80	6485.20	72.80	4.000	47.00	10.0	D	SS
0603	45713.6	51798.3	6486.00	83.00	0.20	6486.20	-	-	-	-	D	NR
0606	44650.3	52042.2	6487.80	35.00	0.30	6488.10	30.30	4.000	25.00	5.0	D	SH
0607	44240.9	51620.4	6527.20	84.00	1.00	6528.20	76.00	4.000	35.00	20.0	U	SH
0609	44917.9	51778.6	6496.40	42.00	-	-	-	-	-	-	N	NR
0610	45585.8	52127.6	6472.60	80.00	0.20	6472.80	80.20	4.000	65.00	15.0	D	SH
0611	45297.3	51982.9	6483.30	28.00	-	-	-	-	-	-	D	NR
0623	45325.8	51874.0	6483.50	30.00	0.50	6484.00	29.50	4.000	21.00	5.0	D	GP
0624	45134.9	51925.8	6487.30	138.00	0.50	6487.80	138.50	4.000	123.00	15.0	O	SS
0625	45256.6	51940.8	6482.60	30.00	0.70	6483.30	29.70	4.000	19.00	5.0	D	GP

* DEPTH GIVEN IN FEET BELOW GROUND SURFACE

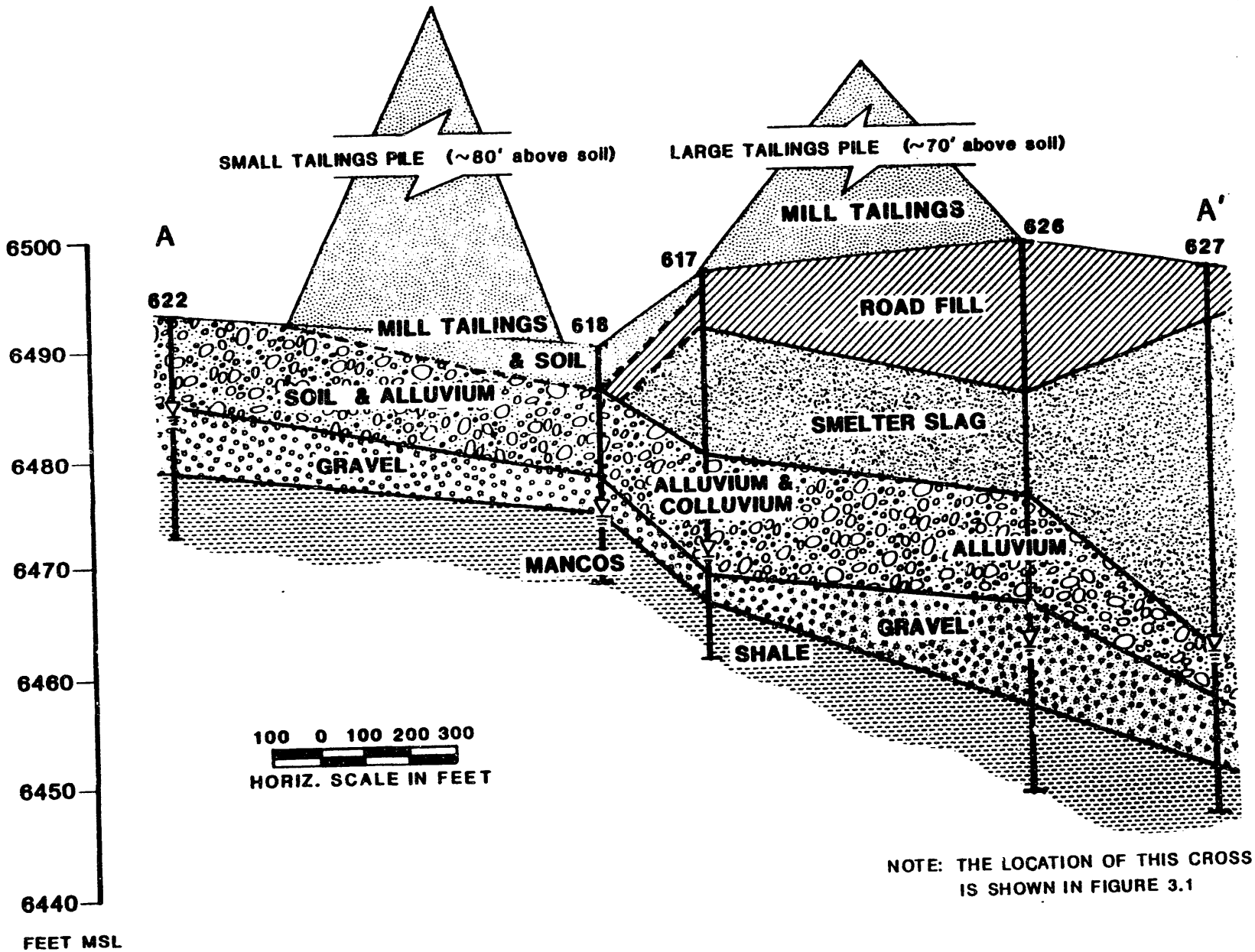
+ CASING DIAMETER = INSIDE DIAMETER

FORMATION OF COMPLETION CODE:
SH - SHALE
SS - SANDSTONE
NR - NO RECOVERY OF DATA FOR CLASSIFYING
GP - GRAVEL OR SANDY GRAVEL, POORLY GRADED

FLOW RELATIONSHIP CODE:
C - CROSS GRADIENT
D - DOWN GRADIENT
U - UPGRADIENT
N - UNKNOWN
O - ON-SITE

DATA FILE: M:\DART\DUR02\MWI10000.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE



NOTE: THE LOCATION OF THIS CROSS SECTION IS SHOWN IN FIGURE 3.1

FIGURE 3.2
GEOLOGIC CROSS SECTION (A-A') OF FORMER TAILINGS PILES AREA
DURANGO PROCESSING SITE, COLORADO

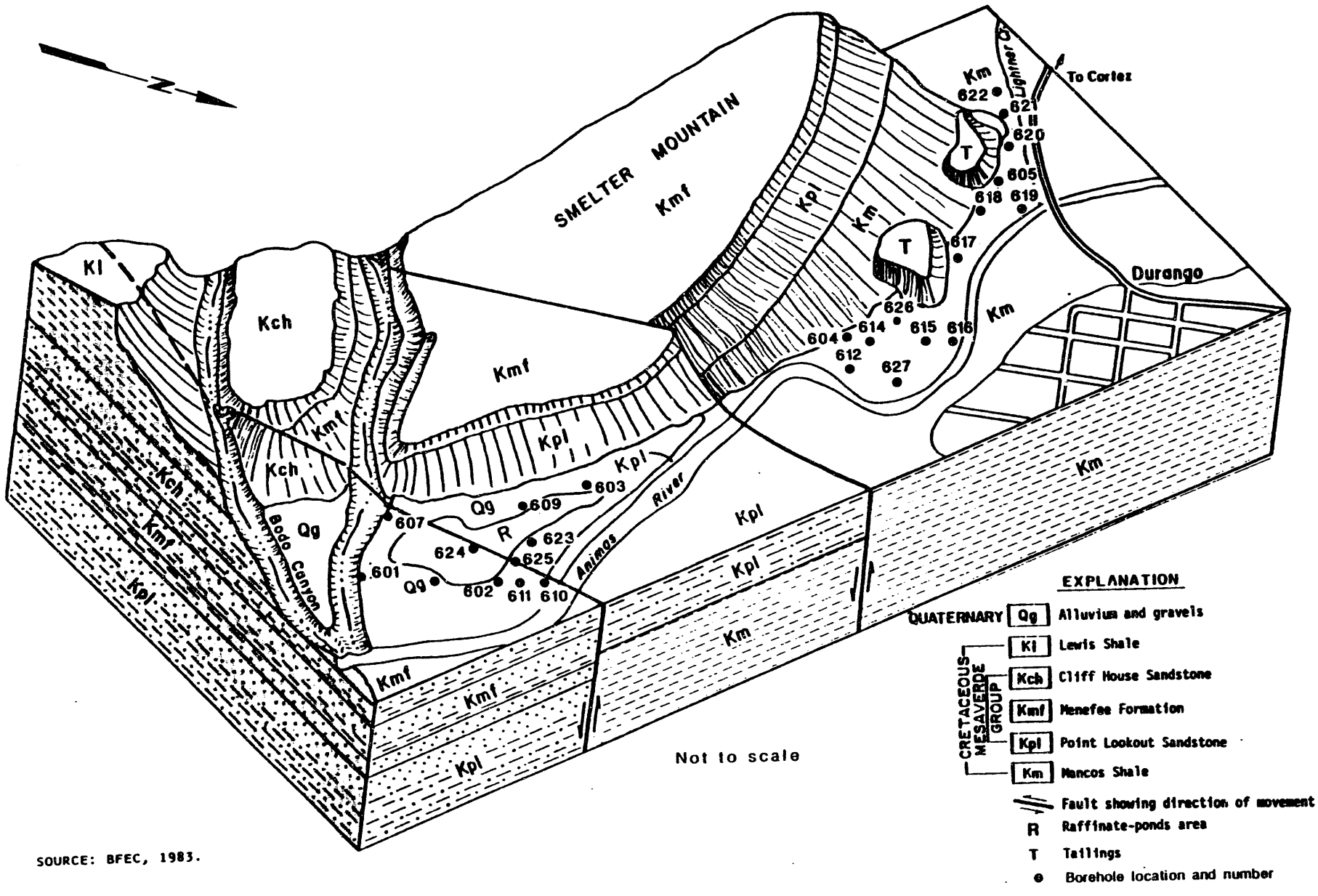
Formation. The Point Lookout Sandstone underlies the western portion of the raffinate ponds area and the Menefee Formation underlies the eastern portion (Figure 3.3). These two formations dip to the southeast at an average of nine degrees. The raffinate ponds area is separated by a northeast-trending normal fault. The fault dips 52 to 59 degrees southeast and is characterized by up to one foot of gray clayey gouge (USBR, 1990). In this area, the Point Lookout Sandstone consists of siltstone with interbedded sandstone and minor shale (USBR, 1990). The Menefee Formation, which underlies the eastern side of the fault, consists of massive sandstone, shale, carbonaceous shale, and coal. The coal is brittle, laminated to thinly bedded, and intensely fractured (USBR, 1990). A geologic cross section of the raffinate ponds area is shown in Figure 3.4. The cross section location is shown in Figure 3.1.

3.1.3 Presence and movement of groundwater

Unconfined groundwater occurs within the alluvium and colluvium at the processing site. The alluvial aquifer is recharged by infiltration of incident precipitation and surface runoff and by inflow from Lightner Creek and the Animas River during periods of high flow. Groundwater in the alluvium generally flows to the southeast subparallel to the Animas River. Discharge from the alluvium is to the Animas River during periods of low flow. Depths to groundwater measured in shallow monitor wells screened in the alluvium generally range from eight to 11 feet. In the raffinate ponds area alluvial saturation occurs locally where the water table surface rises above the bedrock (USBR, 1990). Seasonal water table fluctuations in the alluvial aquifer generally are two to three feet. However, water table elevations recorded in monitor well 607 near an ephemeral stream and the fault zone exhibit fluctuations of up to 12 feet seasonally.

The spatial distribution of water level data from existing monitor wells is not sufficient to render water table or potentiometric surface maps. Groundwater flow velocities in the alluvium are on the order of one foot per day, based on water level and hydraulic conductivity data reported by BFEC (1983).

The Mancos Shale contains small quantities of groundwater in sandstone lenses and in fractured or weathered sections. Coal and sandstone beds within the Menefee Formation and the brecciated fault zone contain groundwater. The shales of the Point Lookout Sandstone contain only minor quantities of groundwater. Recharge to the bedrock is probably from the downward flow of groundwater through the overlying alluvium and from groundwater underflow. Discharge of groundwater from the bedrock may be to the Animas River, and some groundwater flow may move downdip or downward to deeper formations. Depths to the bedrock piezometric surface in the former tailings area range from 15 to 27 feet. Water levels in shallow bedrock monitor well 619 average five feet below ground surface; however, this well is located in an area where the bedrock is very close to



SOURCE: BFEC, 1983.

FIGURE 3.3
GENERALIZED GEOLOGY AND BOREHOLE LOCATIONS
DURANGO PROCESSING SITE, COLORADO

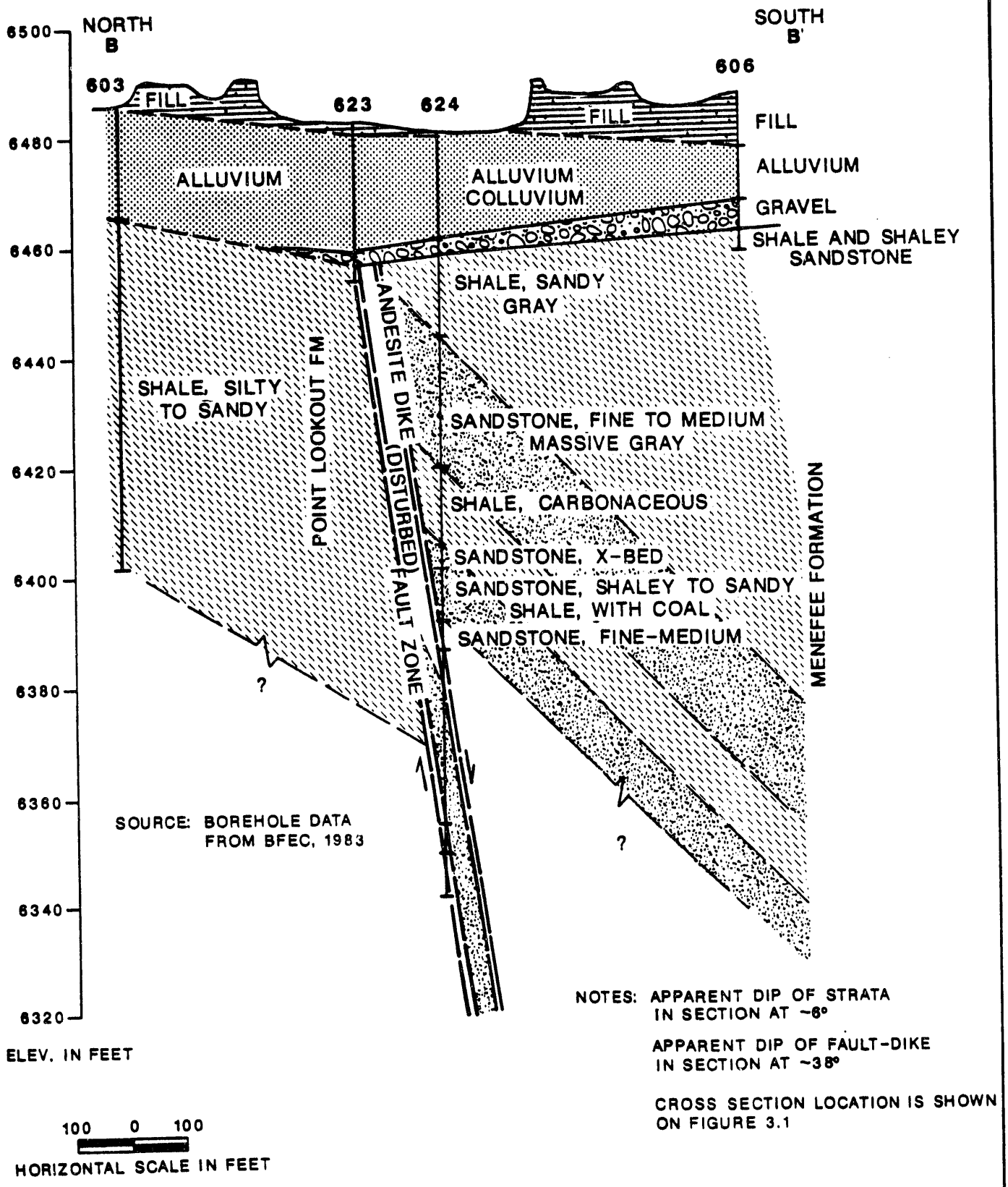


FIGURE 3.4
GEOLOGIC CROSS SECTION (B-B') OF DURANGO RAFFINATE PONDS AREA
DURANGO PROCESSING SITE

the ground surface. In the raffinate ponds area, depth to the potentiometric surface ranges from 23 to 50 feet. Seasonal fluctuations in the potentiometric surface elevation range from 10 feet in the former tailings area to five feet in the raffinate ponds area.

3.1.4 Hydraulic characteristics

In 1982, BFEC (1983) performed slug-withdrawal tests on eleven monitor wells in both the former tailings pile and the raffinate ponds areas (Table 3.2). In the former tailings area, five of the wells tested were screened in the alluvial system and one was screened in the Mancos Shale Formation. In the raffinate ponds area, two of the wells tested were screened in the alluvial system and three bedrock wells were tested. The slug tests were conducted by an air lifting technique that was used to remove water from the well bore (BFEC, 1983). The Hvorslev method (Hvorslev, 1951) for unconfined aquifers was used to determine the hydraulic conductivities. In 1990, the U.S. Bureau of Reclamation issued a hydrogeochemical characterization report for the former raffinate ponds area. The USBR performed packer, bailout, and slug tests in the Menefee, Cliff House, and Point Lookout Formations, as well as the fault zone. The results of these tests are included in the following discussion.

The alluvial materials exhibited the highest hydraulic conductivities, ranging from 20 ft/day (0.007 cm/s) to 380 ft/day (0.1 cm/s). The Mancos Shale in the former tailings area exhibited a hydraulic conductivity ranging from 6 ft/day (0.002 cm/s) to 30 ft/day (0.01 cm/s). Hydraulic conductivities range from 0.006 ft/day (2×10^{-6} cm/s) to 23 ft/day (0.008 cm/s) in the Menefee Sandstone, siltstone, and coal. Hydraulic conductivities range from 0.12 ft/day (4×10^{-5} cm/s) to 2.1 ft/day (7×10^{-4} cm/s) in the Point Lookout Sandstone were reported for the raffinate ponds area. A hydraulic conductivity ranging from 0.2 ft/day (7×10^{-5} cm/s) to 7 ft/day (3×10^{-3} cm/s) was determined for the fault zone in the raffinate ponds area (BFEC, 1983; and USBR, 1990). Average groundwater flow velocities were determined to be approximately one foot per day for the alluvial aquifer system and range from four to 20 ft/day in the fault zone (BFEC, 1983).

3.1.5 Background groundwater quality

Background groundwater quality is defined as the quality of groundwater that would be expected at the site if processing of uranium had not occurred. Background water quality in the alluvium has been determined by chemical analysis of water samples collected from a monitor well located in an area hydraulically upgradient from the raffinate ponds area. Monitor well 607 was completed at the alluvium/bedrock contact adjacent to a fault (Figure 3.3). Monitor well 607 monitors groundwater in the vicinity of South Creek that is recharging the alluvial aquifer in the raffinate ponds area.

Table 3.2 Hydraulic conductivities determined from bail-test data, Durango processing site, Colorado (BFEC, 1983)

Well number	Hydraulic conductivity						Formation of completion
	Trial 1		Trial 2		Trial 3		
	ft/day	cm/s	ft/day	cm/s	ft/day	cm/s	
602	1	4×10^{-4}	-	-	-	-	Pl
603	6×10^{-3}	2×10^{-6}	-	-	-	-	Mf
606	23	8×10^{-3}	22	8×10^{-3}	23	8×10^{-3}	Mf
610	5	2×10^{-3}	4	1×10^{-3}	4	1×10^{-3}	Mf
612	8	3×10^{-3}	6	2×10^{-3}	6	2×10^{-3}	M
615	21	7×10^{-3}	35	0.01	-	-	Al
616	26	9×10^{-3}	22	8×10^{-3}	26	9×10^{-3}	Al
619	29	0.01	28	0.01	30	0.01	M
621	260	0.09	370	0.1	380	0.1	Al
623	23	8×10^{-3}	20	7×10^{-3}	22	8×10^{-3}	Al
624	0.1	4×10^{-5}	-	-	-	-	Pl

Monitor well locations are shown in Figure 3.1.

The values in cm/s were rounded to one significant figure.

Al - Alluvium.
M - Mancos Shale.
Pl - Point Lookout Sandstone.
Mf - Menefee Formation.
- indicates no data available.

Background water quality was characterized by analyzing constituents listed in Table 8.1 of the Technical Approach Document (TAD) (DOE, 1989). A statistical analysis of background water quality in the alluvial system that includes the minimum, mean, median, maximum, percentage of nondetects, the 99 percent confidence interval, and other important statistical parameters is provided in Table 3.3. For characterization purposes, background water quality can be characterized by describing an average concentration and a statistical maximum. The procedures for calculating average and statistical maximum concentrations are discussed in "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities-Interim Final Guidance" (EPA, 1989) and are described in the TAD. Average concentrations of hazardous constituents are represented statistically by a mean or median depending on the proportion of nondetects and whether the distribution is normal or nonparametric. The statistical maximum may be represented as the 99 percent confidence maximum for normal or lognormal distributions or a nonparametric confidence interval if the distribution is neither normal nor log normal. In some cases, it is not appropriate to use statistics and the maximum observed concentration is chosen as a "statistical maximum." In other cases, the statistical maximum may be the detection limit.

Analyses of groundwater samples indicate that maximum background concentrations of cadmium, chromium, molybdenum, net gross alpha (gross alpha minus uranium), and selenium have exceeded the proposed EPA maximum concentration limits (MCLs) (Table 3.3). Cadmium exceeded MCLs once in 1988. Chromium exceeded MCLs twice in 1988. Molybdenum exceeded MCLs twice in 1987. Net gross alpha exceeded MCLs twice in 1988. Selenium exceeded MCLs eight times from 1987 through 1989. However, no 98 percent confidence interval statistical minima of these hazardous constituents exceeded proposed EPA MCLs. No background groundwater samples were analyzed for priority pollutant organics. Background water quality in monitor well 607 is a mixed magnesium/sodium sulfate type with TDS ranging from 1670 to 4910 mg/l and pH ranging from 6.6 to 8.3.

3.1.6 Tailings and milling process characterization

From the 1880s to 1930, a lead smelter operated at the Durango site. During this period, the smelting operation created a slag pile stretching from the base of Smelter Mountain to the Animas River, north and east of the mill site. At the river's edge, the slag is about 40 feet deep. In 1941, the United States Vanadium Corporation (USV) designed and built a mill on the site of the old lead smelter to furnish vanadium to the Metals Reserve Company. Starting in 1943, USV also reprocessed the vanadium tailings for the recovery of uranium for the Manhattan Project. In 1949, the USV mill was reopened by the Vanadium Corporation of America and operated until March 1963, under a contract to sell uranium to the U.S. Atomic Energy Commission. The initial milling capacity of about 175 tons of ore per day was expanded to 430 tons per day by 1956, and to 750 tons per day by 1958. During the 14-year period of operations,

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	13	297.0000	506.0000	394.0000	375.5385	57.4291	0.1529	0.0	332.8356	418.2413	NORMAL	
ALUMINUM	MG/L	2	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	3	** 0.1000	0.1000	** 0.1000	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
ANTIMONY	MG/L	6	** 0.0030	0.0150	** 0.0030	NA	NA	NA	83.3	** 0.0030	0.0150	NONPARAMETRIC	2,6
ARSENIC	MG/L	13	0.0020	0.0300	0.0050	NA	NA	NA	69.2	0.0050	0.0190	NONPARAMETRIC	2
BARIUM	MG/L	10	0.0200	0.0500	+ 0.0500	NA	NA	NA	70.0	0.0200	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	6	** 0.0050	0.0050	+ 0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2,6
CADMIUM	MG/L	13	** 0.0010	0.0120	0.0010	NA	NA	NA	61.5	** 0.0010	0.0040	NONPARAMETRIC	2
CALCIUM	MG/L	13	147.0000	560.0000	202.0000	226.0769	108.7539	0.4810	0.0	145.2102	306.9437	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	1	4.0000	4.0000	4.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE	MG/L	13	46.0000	740.0000	68.0000	97.9195	2.3529	NA	0.0	51.8265	185.0062	LOGNORMAL	7,8
CHROMIUM	MG/L	10	** 0.0100	0.1200	** 0.0100	NA	NA	NA	80.0	** 0.0100	0.0800	NONPARAMETRIC	2
COBALT	MG/L	6	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	** 0.0300	** 0.0300	NONPARAMETRIC	2,6
COPPER	MG/L	10	** 0.0100	0.0200	+ 0.0100	NA	NA	NA	90.0	** 0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	6	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2,6
FLUORIDE	MG/L	10	0.2000	0.7000	+ 0.5000	0.4830	0.1300	0.2691	0.0	0.3671	0.5989	NORMAL	
GROSS ALPHA	PCI/L	10	3.0000	42.0000	+ 16.0000	17.8500	11.9402	0.6689	0.0	7.1984	28.5016	NORMAL	
GROSS BETA	PCI/L	10	4.0000	40.0000	+ 14.8000	16.8200	11.3245	0.6733	0.0	6.7177	26.9223	NORMAL	
IRON	MG/L	13	0.0400	5.6000	0.2000	0.2707	5.1055	NA	0.0	0.0805	0.9099	LOGNORMAL	7,8

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
LEAD	MG/L	10	** 0.0050	0.0100	+ 0.0050	NA	NA	NA	90.0	0.0050	0.0050	NONPARAMETRIC	2
MAGNESIUM	MG/L	13	102.0000	370.0000	142.0000	162.4615	71.9752	0.4430	0.0	108.9425	215.9806	NORMAL	
MANGANESE	MG/L	13	0.7700	2.9800	1.7900	1.7085	0.6423	0.3760	0.0	1.2399	2.18[illegible]1	NORMAL	
MERCURY	MG/L	13	** 0.0002	0.0008	** 0.0002	NA	NA	NA	76.9	** 0.0002	0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	13	** 0.0100	0.1700	0.0200	NA	NA	NA	38.5	** 0.0100	0.0800	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	10	0.7400	33.0800	+ 13.6750	14.9150	10.6941	0.7170	0.0	5.3751	24.4549	NORMAL	
NICKEL	MG/L	7	** 0.0400	0.0500	** 0.0400	NA	NA	NA	85.7	** 0.0400	0.0500	NONPARAMETRIC	2
NITRATE	MG/L	10	** 1.0000	11.5000	+ 1.4000	NA	NA	NA	40.0	** 1.0000	6.3000	NONPARAMETRIC	2
NITRITE	MG/L	1	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NITRITE AND NITRATE	MG/L	2	0.4000	0.5000	+ 0.4500	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
PH	SU	13	6.6000	8.3300	6.8900	NA	NA	NA	0.0	NA	NA	UNKNOWN	
POTASSIUM	MG/L	13	4.7000	8.1000	5.7100	5.8731	0.9739	0.1658	0.0	5.1489	6.5972	NORMAL	
RADIUM-226	PCI/L	13	** 0.1000	0.4000	0.2000	NA	NA	NA	15.4	** 0.1000	0.4000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	12	0.1000	2.4000	+ 0.6750	0.8167	0.6777	0.8298	0.0	0.2850	1.3484	NORMAL	
RADIUM-228	PCI/L	12	** 0.8000	2.2000	** 0.8000	NA	NA	NA	16.7	** 0.8000	1.2000	NONPARAMETRIC	2
REDOX POTENTIAL	mVOLTS	1	244.2000	244.2000	244.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	13	0.0020	0.0670	0.0220	NA	NA	NA	30.8	0.0025	0.0400	NONPARAMETRIC	2
SILVER	MG/L	13	** 0.0100	0.0300	** 0.0100	NA	NA	NA	76.9	** 0.0100	0.0200	NONPARAMETRIC	2
SODIUM	MG/L	13	249.0000	570.0000	314.0000	363.7692	110.8514	0.3047	0.0	281.3429	446.1956	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SPECIFIC CONDUCTANCE	UMHO/CM	13	1400.0000	4150.0000	2000.0000	2284.2308	798.8216	0.3497	0.0	1690.2465	2878.2151	NORMAL	
STRONTIUM	MG/L	2	1.5200	1.5800	+ 1.5500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE	MG/L	13	923.0000	2360.0000	1320.0000	1409.6154	424.2141	0.3009	0.0	1094.1801	1725.0506	NORMAL	
SULFIDE	MG/L	6	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,6
TEMPERATURE	C - DEGREE	13	11.0000	24.0000	13.0000	13.5385	3.2585	0.2407	0.0	11.1155	15.9614	NORMAL	
THALLIUM	MG/L	6	** 0.0100	0.0150	** 0.0100	NA	NA	NA	100.0	** 0.0100	0.0150	NONPARAMETRIC	2,6
THORIUM-230	PCI/L	3	** 0.1000	0.6000	0.1000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
TIN	MG/L	6	** 0.0050	0.0690	+ 0.0165	NA	NA	NA	50.0	** 0.0050	0.0690	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS	MG/L	13	1670.0000	4910.0000	2620.0000	2693.0769	962.1191	0.3573	0.0	1977.6687	3408.4852	NORMAL	
URANIUM	MG/L	13	** 0.0010	0.0130	0.0033	0.0039	0.0032	0.8178	7.7	0.0015	0.0063	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.3 - BACKGROUND MONITOR WELL 607, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM	MG/L	7	** 0.0100	0.0200	** 0.0100	NA	NA	NA	57.1	** 0.0100	0.0200	NONPARAMETRIC	2
ZINC	MG/L	10	0.0060	0.0320	+ 0.0190	0.0184	0.0091	0.4978	10.0	0.0102	0.0265	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

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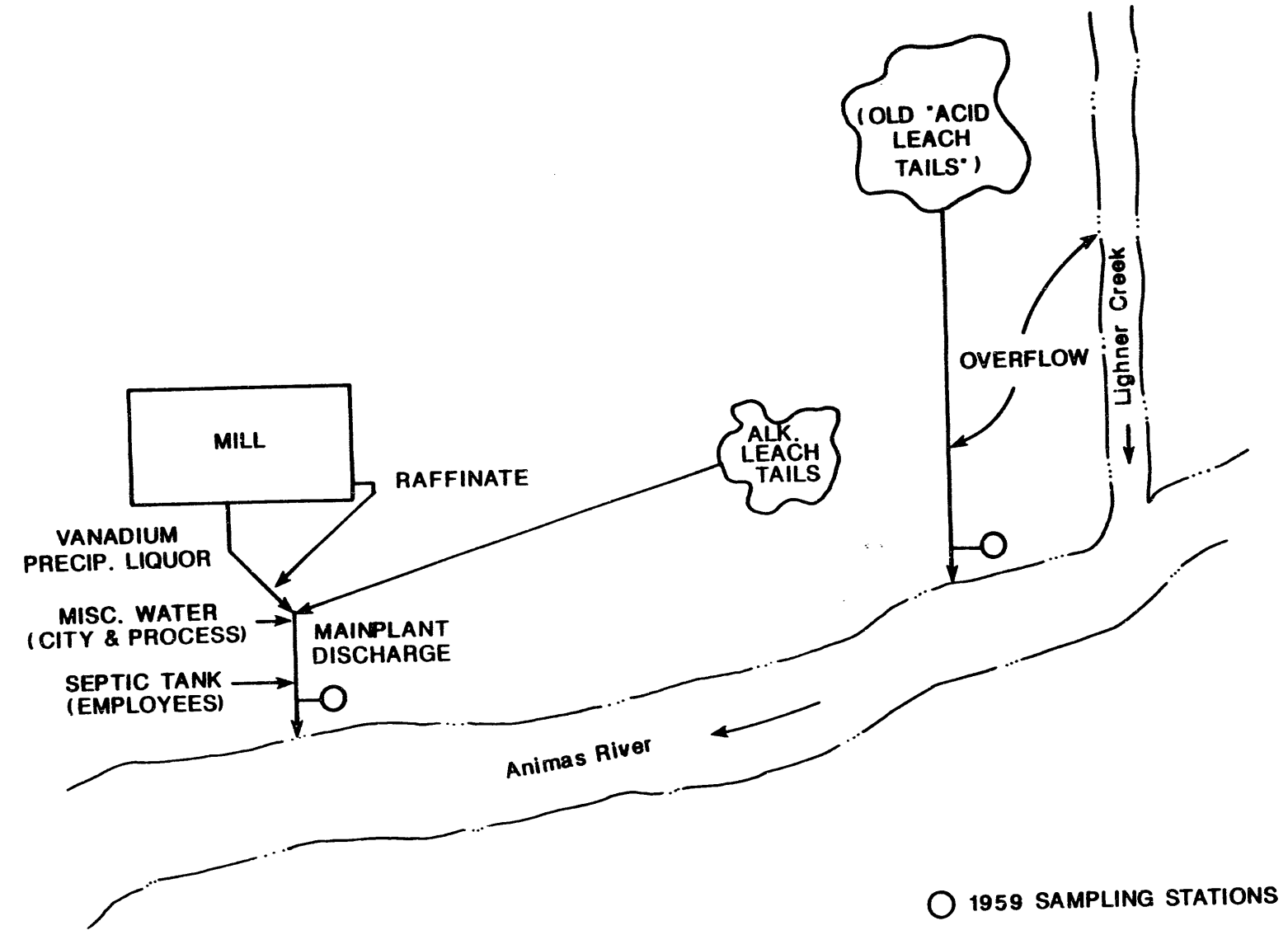
about 1.6 million tons of ore were processed. Ore averaging 0.29 percent uranium oxide and 1.6 percent vanadium oxide was trucked to the Durango mill from all parts of the Uravan Mineral Belt. All active milling operations at the site ended in March 1963.

Concentrates from the company upgrader plants and ores were salt roasted. The calcines were quenched in carbonate solutions, and treated by countercurrent washing. Pregnant solutions were treated to precipitate uranium, filtered, and the filtrate was further processed to recover vanadium. Tailings from the carbonate leaching operation were acid-leached for additional uranium and vanadium recovery. The pregnant (uranium and vanadium laden) acid-leach liquor was treated by solvent extraction to recover both uranium and vanadium. Prior to 1959, the principal wastes from the process included vanadium precipitation liquor, raffinate from the organic solvent extraction process, overflow from alkaline leach tails, iron aluminum sludge, and acid leach tails. These waste liquors were discharged directly into the Animas River or Lightner Creek without treatment. The discharges caused elevated concentrations of radiological parameters in the Animas River as far downstream as the Farmington, New Mexico, water intake, which led to abatement action by the states of New Mexico and Colorado and the Federal government (FBDU, 1981).

In 1959, the process was changed and the acid-leach tails, alkaline leach tails overflow, roaster gas scrubbing sludge, and process water overflow were pumped to a settling pond on the top of the main tailings pile. Overflow from this pond was carried by a flume to a small mixing tank where barium sulfate and Separan^R were added before the solution flowed to the lower pond on the top of the north (small) tailings pile for further settling (Figure 3.5). The effluent from the north pond was discharged into the Animas River. This effluent treatment was designed to remove as much of the slimes and dissolved radium as possible before discharge to the river.

Raffinate from the solvent extraction process was pumped to a tank on the hill behind the mill and flowed through approximately 300 feet of plastic pipe to a small flume. From here it discharged into a ditch that ran southward for about 3000 feet to a tract of company-owned land. The flow then proceeded through about 3000 additional feet of terrace consisting of a convoluted ditch proceeding eastward toward the river. The liner material, if any, of these ditches is unknown. The terrace discharged into a lagoon about one acre in area. A second lagoon about two acres in area was provided for use when the first lagoon was filled. There was no direct discharge to the river from these lagoons; the object of this arrangement was to dispose of the waste through evaporation and seepage. The principal liquid waste component remaining in the main plant effluent after 1959 was the vanadium precipitation liquor. This liquor was diluted with overflow from a process water tank, condensed steam, a small quantity of wastes from the septic tank serving the plant, and miscellaneous plant and process water, and then discharged into the Animas River.



NOTE: AFTER BFEC, 1983.

FIGURE 3.5
VCA MILL WASTE LIQUOR FLOWS
DURANGO PROCESSING SITE, COLORADO

The tailings at the Durango site consisted of interlayered sands and slimes (clay and silt-sized particles) produced during the processing of uranium ore. Former locations of the tailings piles are shown in Figure 3.1. Several types of materials made up the Durango tailings piles: uranium tailings, vanadium tailings, lead smelter slag, rubble, and contaminated earth (FBDU, 1981). The tailings are a mixture of processed ore material and the chemicals used in the extraction process. The uranium/vanadium tailings have a low clay content. Based upon two borings, the average bulk density of the tailings is 98.3 pounds per cubic foot. Estimates of uranium and vanadium content of the Durango tailings piles were made by FBDU (1981), Ranchers Exploration and Development Corporation (REDC) (1978), and by Jacobs Engineering Group. Estimates of uranium oxide content in the tailings ranged from 1.16 million pounds (REDC, 1978) to 1.49 million pounds (FBDU, 1981). Vanadium oxide content estimates ranged from 9.33 million pounds (REDC, 1978) to 16.13 million pounds (DOE, 1984a).

The chemical characteristics of the tailings were evaluated by pore water sampling with suction lysimeters. Eight suction lysimeters were installed in the tailings piles by the DOE in 1987. Three of the lysimeters were installed near the base of the small pile, and five were installed into the base of the large pile. Installation depths ranged from approximately five to 10 feet. The lysimeters were sampled in April 1987. They produced sufficient sample volume for analysis of major cations and anions, radium-226 and -228, and uranium. The lysimeter sample pH values ranged from 7.6 to 8.3, with a mean value of 8.0. Activities of radium-226 and -228 and concentrations of uranium exceeded the laboratory method detection limits and MCLs. Dissolved levels of radium-226 in the pore water samples ranged from 1.3 to 33 picocuries per liter (pCi/l). Uranium concentrations ranged from 0.047 mg/l to 2.89 mg/l.

After the tailings were relocated to the Bodo Canyon disposal site, monitor wells screened within the tailings were installed and the pore water was sampled. Tailings pore water quality statistics by parameter for these wells are presented in Table 3.4. Inorganic hazardous constituents with MCLs with concentrations that exceed the laboratory method detection limits in tailings pore water are listed in this table and include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Elements listed individually or included in compounds that are listed in Appendix I of 40 CFR 192 or in Appendix IX of 40 CFR 264 with concentrations that exceed the laboratory method detection limit include ammonium, beryllium, cobalt, copper, fluoride, nickel, vanadium, and zinc. Aluminum, antimony, and strontium concentrations were not determined, but it is assumed that concentrations of these elements exceed laboratory method detection limits based on data from tailings piles at other uranium processing sites.

Elements in hazardous constituent compounds were also analyzed. The four elements of hazardous compounds and their respective hazardous compounds are the following: 1) aluminum as aluminum

TABLE 3.4 - TAILINGS MONITOR WELLS, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	15	303.0000	770.0000	590.0000	534.4000	164.6979	0.3082	0.0	422.8149	645.9851	NORMAL	
AMMONIUM	MG/L	5	0.5000	2.2000	0.5000	1.0800	0.8136	0.7534	0.0	** 0.1000	2.4434	NORMAL	
ARSENIC	MG/L	15	0.0900	0.5700	0.1900	0.2433	0.1386	0.5697	0.0	0.1494	0.3373	NORMAL	
BARIUM	MG/L	15	0.0200	0.0600	0.0500	NA	NA	NA	66.7	0.0300	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	15	** 0.0100	0.1600	** 0.0100	NA	NA	NA	66.7	** 0.0100	0.1000	NONPARAMETRIC	2
CADMIUM	MG/L	15	0.0140	0.0630	0.0370	0.0355	0.0155	0.4374	0.0	0.0250	0.0460	NORMAL	
CALCIUM	MG/L	15	513.0000	609.0000	583.0000	564.1333	35.8725	0.0636	0.0	539.8292	588.4375	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	5	12.0000	52.0000	22.0000	28.4000	15.7734	0.5554	0.0	** 5.0000	54.8316	NORMAL	
CHLORIDE	MG/L	15	59.0000	210.0000	75.0000	98.5533	55.6753	0.5649	0.0	60.8325	136.2742	NORMAL	
CHROMIUM	MG/L	15	** 0.0100	0.2600	** 0.0100	NA	NA	NA	66.7	** 0.0100	0.1800	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

TABLE 3.4 - TAILINGS MONITOR WELLS, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COBALT	MG/L	5	0.0700	0.2000	0.1100	0.1280	0.0492	0.3843	0.0	** 0.0500	0.2104	NORMAL	
COPPER	MG/L	15	0.0300	0.0600	0.0400	0.0447	0.0106	0.2373	0.0	0.0375	0.0518	NORMAL	
CYANIDE	MG/L	10	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
FLUORIDE	MG/L	15	0.4000	1.6000	0.6000	0.7333	0.4012	0.5471	0.0	0.4615	1.0051	NORMAL	
GROSS ALPHA	PCI/L	15	820.0000	14200.0000	2900.0000	4288.0000	3983.8804	0.9291	0.0	1588.8658	6987.1342	NORMAL	
GROSS BETA	PCI/L	15	330.0000	4300.0000	780.0000	1340.0000	1246.8131	0.9305	0.0	495.2668	2184.7332	NORMAL	
IRON	MG/L	15	0.0900	0.6300	0.1400	0.2140	0.1722	0.8047	0.0	0.0973	0.3307	NORMAL	
LEAD	MG/L	15	** 0.0100	0.0200	** 0.0100	NA	NA	NA	53.3	** 0.0100	0.0200	NONPARAMETRIC	2
MAGNESIUM	MG/L	15	41.2000	166.0000	68.5000	79.2133	42.2838	0.5338	0.0	50.5655	107.8612	NORMAL	
MANGANESE	MG/L	15	3.0300	8.6300	6.0100	5.6407	1.4050	0.2491	0.0	4.6888	6.5925	NORMAL	

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

TABLE 3.4 - TAILINGS MONITOR WELLS, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MERCURY	MG/L	15	** 0.0002	0.0004	** 0.0002	NA	NA	NA	66.7	** 0.0002	0.0003	NONPARAMETRIC	2
MOLYBDENUM	MG/L	15	0.8100	3.9800	1.7300	1.9460	1.0904	0.5603	0.0	1.2073	2.6847	NORMAL	
NET GROSS ALPHA ***	PCI/L	15	-4331.6000	66.6000	-519.4600	NA	NA	NA	0.0	-854.2600	-188.4200	NONPARAMETRIC	9
NICKEL	MG/L	5	** 0.0400	0.0700	0.0400	NA	NA	NA	40.0	** 0.0400	0.0700	NONPARAMETRIC	2,5
NITRATE	MG/L	15	** 1.0000	22.0000	1.6000	NA	NA	NA	40.0	** 1.0000	4.5000	NONPARAMETRIC	2
PH	SU	15	6.2900	7.5700	6.6300	NA	NA	NA	0.0	NA	NA	UNKNOWN	
POTASSIUM	MG/L	15	12.6000	30.6000	17.2000	19.8467	6.4953	0.3273	0.0	15.4460	24.2473	NORMAL	
RADIUM-226	PCI/L	15	5.9000	18.0000	9.9000	10.5067	3.3484	0.3187	0.0	8.2380	12.7753	NORMAL	
RADIUM-226 + RADIUM-228	PCI/L	15	6.6000	18.4000	10.1000	10.9800	3.3554	0.3056	0.0	8.7067	13.2533	NORMAL	

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.4 - TAILINGS MONITOR WELLS, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-228	PCI/L	15	** 0.8000	0.8000	** 0.8000	NA	NA	NA	33.3	** 0.8000	** 0.8000	NONPARAMETRIC	2
SELENIUM	MG/L	15	0.0450	0.4080	0.1320	0.1745	0.1237	0.7091	0.0	0.0906	0.2583	NORMAL	
SILVER	MG/L	15	** 0.0100	0.0700	** 0.0100	NA	NA	NA	53.3	** 0.0100	0.0400	NONPARAMETRIC	2
SODIUM	MG/L	15	122.0000	727.0000	228.0000	371.9333	248.5048	0.6681	0.0	203.5679	540.2988	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	15	1850.0000	3800.0000	2100.0000	2576.6667	755.4248	0.2932	0.0	2064.8559	3088.4775	NORMAL	
SULFATE	MG/L	15	1540.0000	2800.0000	1710.0000	2029.3333	482.1302	0.2376	0.0	1702.6834	2355.9832	NORMAL	
SULFIDE	MG/L	5	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	** 0.1000	** 0.1000	NONPARAMETRIC	2,5
TEMPERATURE	C - DEGREE	15	9.0000	15.0000	11.5000	11.5000	1.8127	0.1576	0.0	10.2719	12.7281	NORMAL	
THALLIUM	MG/L	15	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
TIN	MG/L	5	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	** 0.0050	** 0.0050	NONPARAMETRIC	2,5

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

TABLE 3.4 - TAILINGS MONITOR WELLS, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TOTAL DISSOLVED SOLIDS	MG/L	15	2790.0000	5080.0000	3250.0000	3710.0000	910.0628	0.2453	0.0	3093.4198	4326.5802	NORMAL	
TOTAL ORGANIC CARBON	MG/L	5	116.0000	169.0000	125.0000	137.2000	23.7634	0.1732	0.0	97.3794	177.0206	NORMAL	
URANIUM	MG/L	15	1.4700	21.6000	4.5400	7.4120	6.8766	0.9278	0.0	2.7530	12.0710	NORMAL	
VANADIUM	MG/L	5	5.7000	14.4000	11.1000	10.4720	3.9374	0.3760	0.0	3.8741	17.0699	NORMAL	
ZINC	MG/L	15	0.1920	4.7900	2.0200	2.1270	1.5515	0.7294	0.0	1.0758	3.1782	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, α = 0.01

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phosphide; 2) ammonium as a salt of vanadic acid; 3) fluoride as carbon oxyfluoride; and 4) strontium as strontium sulfide. None of these four compounds would exist under normal geochemical conditions expected of uranium mill tailings. Therefore, these hazardous compounds and their respective elements are not considered as hazardous constituents at the Bodo Canyon disposal site.

For characterization purposes, mean or median tailings pore water quality data were compared to MCLs. Mean or median observed concentrations or activities of arsenic, cadmium, molybdenum, radium-226 and -228, selenium, and uranium in tailings pore water exceeded the MCLs as shown in Table 3.4. For hazardous constituents with no MCLs, mean or median tailings pore water quality data were compared to the statistical maximum of background groundwater quality to determine the potential for any of these constituents to be groundwater contaminants at the processing site. The mean or median concentrations of four hazardous constituents that do not have MCLs, cobalt, copper, vanadium, and zinc, exceeded the statistical maximum of background groundwater quality, and therefore they are potential groundwater contaminants at the processing site.

3.1.7 Extent of existing contamination

To assess the extent of groundwater contamination at the Durango processing site caused by seepage of leachate from the tailings piles and previous processing activities, groundwater quality data have been collected by the DOE on a quarterly basis since 1985 from five downgradient monitoring wells. Three of the monitor wells (612, 617, 622) are completed in the alluvium downgradient of the former tailings pile area, and two monitor wells (602, 603) are completed in bedrock and are located downgradient of the raffinate ponds area (Figure 3.1). One screened interval in bedrock monitor well 602 is completed in a sandstone unit of the Menefee Shale and another screened interval is completed in a Menefee coal seam. Bedrock monitor well 603 was completed as an uncased borehole open in the Point Lookout Sandstone from 23 to 83 feet below ground surface (Table 3.1). Constituents analyzed in groundwater samples are listed in Table 8.1 of the TAD.

Former tailings area

An oxidizing agent was used during the processing of uranium and vanadium; therefore, the oxidation potential in the groundwater beneath the site is elevated. The pH of the alluvial groundwater was controlled by the presence of alkaline leach tailings at the toe of the large tailings pile and the groundwater characterization indicated a neutral to alkaline pH (6.9 to 8.6). Under these conditions, hazardous constituents present as oxyanions or complex carbonate anions will be mobile; for example, uranium, selenium, arsenic, and molybdenum.

At the time that the vanadium recovery mill was constructed on the Durango site (1942), slag heaps from a lead-silver smelter were leveled to provide the site foundation. There is up to 25 feet of slag overlying the Animas River gravels beneath the site. The slags are vitreous and contain high concentrations of lead. The uranium mill tailings were subjected to salt roasting, leaching by both carbonate and acid solutions and oxidized with potassium permanganate (K_2MnO_4). The tailings were then slurried into place against the north face of Smelter Mountain and upon the lead-silver slag foundation. The Colorado Department of Health (CDH) conducted EP toxicity tests on the slag material in 1989. These tests indicated that only lead is leachable from this material.

A statistical analysis of alluvial groundwater quality from 1987 through 1990 is presented in Table 3.6. Hazardous constituents with MCLs and with concentrations or activities that exceeded the laboratory method detection limits in monitor wells at the former tailings area are listed in Table 3.5. These include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, net gross alpha, radium-226 and -228, selenium, silver, and uranium. Elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded the laboratory method detection limits include antimony, copper, fluoride, nickel, sulfide, thallium, tin, vanadium, and zinc.

Maximum observed concentrations of seven hazardous constituents equalled or exceeded MCLs in the alluvial groundwater system downgradient of the former tailings piles area. These constituents include arsenic, cadmium, chromium, molybdenum, net gross alpha, selenium, and uranium. Concentratons of these constituents exceed laboratory method detection limits in the tailings pore water. Therefore, the presence of these hazardous constituents in groundwater may be related to uranium processing activities.

To confirm whether the presence of these hazardous constituents represents groundwater contamination, the lower end of the 98 percent confidence interval for these constituents by monitor well was compared with the MCL. According to "Statistical Analyses of Ground-Water Monitoring Data at RCRA Facilities - Interim Final Guidance" (EPA, 1989), if the lower end of the confidence interval exceeds the MCLs, there is statistical evidence of an exceedance of the MCLs. Because the lower end of the confidence interval does not exceed the MCLs for arsenic, cadmium, chromium, molybdenum, and net gross alpha there is no statistical evidence that they are groundwater contaminants that exceed the MCLs. However, selenium and uranium are the hazardous constituents with concentrations that exceed the MCLs in alluvial groundwater downgradient of the former tailings piles. Because the lower end of the 98 percent confidence interval for the minimum observed concentration exceeds the MCLs for selenium and uranium, there is statistical evidence that concentrations in samples from these monitor wells exceed the MCLs.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	37	86.0000	694.0000	483.0000	453.6216	176.9720	0.3901	0.0	382.8068	524.4364	NORMAL	
ALUMINUM	MG/L	6	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	** 0.0500	0.0500	NONPARAMETRIC	2,6
AMMONIUM	MG/L	9	** 0.1000	0.2000	** 0.1000	NA	NA	NA	66.7	** 0.1000	0.2000	NONPARAMETRIC	2
ANTIMONY	MG/L	17	** 0.0030	0.0230	** 0.0030	NA	NA	NA	76.5	** 0.0030	0.0070	NONPARAMETRIC	2
ARSENIC	MG/L	37	** 0.0060	0.0500	** 0.0060	NA	NA	NA	73.0	** 0.0060	0.0100	NONPARAMETRIC	2
BARIUM	MG/L	30	0.0100	0.0500	+ 0.0500	NA	NA	NA	63.3	0.0400	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	19	** 0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
BORON	MG/L	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CADMIUM	MG/L	37	** 0.0010	0.0610	0.0020	NA	NA	NA	51.4	** 0.0010	0.0240	NONPARAMETRIC	2
CALCIUM	MG/L	37	80.6000	499.0000	394.0000	321.7595	158.4612	0.4925	0.0	258.3517	385.1673	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHEMICAL OXYGEN DEMAND	MG/L	3	12.0000	40.0000	16.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE	MG/L	37	2.1000	795.0000	52.2000	56.3221	6.6321	NA	0.0	26.4179	120.0768	LOGNORMAL	7,8
CHROMIUM	MG/L	31	** 0.0100	0.1600	** 0.0100	NA	NA	NA	80.6	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT	MG/L	17	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	** 0.0300	** 0.0300	NONPARAMETRIC	2
COPPER	MG/L	31	** 0.0100	0.0300	0.0100	NA	NA	NA	87.1	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	19	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
FLUORIDE	MG/L	31	0.1000	1.7000	0.6000	0.7523	0.5250	0.6979	0.0	0.5206	0.9839	NORMAL	
GROSS ALPHA	PCI/L	31	1.6000	3200.0000	130.0000	129.8447	8.8208	NA	0.0	49.6800	339.3648	LOGNORMAL	7,8
GROSS BETA	PCI/L	31	3.8000	1200.0000	71.7000	72.3705	7.4973	NA	0.0	29.7491	176.0552	LOGNORMAL	7,8
IRON	MG/L	37	** 0.0300	0.1500	0.0700	NA	NA	NA	27.0	0.0300	0.1000	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
LEAD	MG/L	31	** 0.0050	0.1500	0.0050	NA	NA	NA	77.4	0.0050	0.0100	NONPARAMETRIC	2
MAGNESIUM	MG/L	37	24.2000	295.0000	195.0000	164.8973	96.8262	0.5872	0.0	126.1526	203.6420	NORMAL	
MANGANESE	MG/L	37	** 0.0100	6.4400	0.0300	NA	NA	NA	21.6	0.0100	4.1000	NONPARAMETRIC	2
MERCURY	MG/L	37	** 0.0002	0.0007	** 0.0002	NA	NA	NA	83.8	** 0.0002	** 0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	37	** 0.0100	0.4200	0.0300	NA	NA	NA	27.0	0.0100	0.1300	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	31	-1046.9000	1556.9400	-2.8900	NA	NA	NA	0.0	-47.0900	6.0200	NONPARAMETRIC	9
NICKEL	MG/L	20	** 0.0400	0.0500	** 0.0400	NA	NA	NA	95.0	** 0.0400	** 0.0400	NONPARAMETRIC	2
NITRATE	MG/L	31	** 1.0000	27.9000	3.6000	3.1431	2.8038	NA	12.9	1.9942	4.9539	LOGNORMAL	7,8
NITRITE	MG/L	3	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NITRITE AND NITRATE	MG/L	6	** 0.9000	1.5000	** 0.9000	NA	NA	NA	50.0	** 0.9000	1.5000	NONPARAMETRIC	2,6
PH	SU	37	6.6000	7.3600	6.8500	NA	NA	NA	0.0	NA	NA	UNKNOWN	
POTASSIUM	MG/L	37	1.7000	44.8000	20.5000	18.7784	13.9266	0.7416	0.0	13.2057	24.3511	NORMAL	
RADIUM-226	PCI/L	37	** 0.1000	0.5000	0.1000	NA	NA	NA	27.0	** 0.1000	0.1000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	35	0.0000	2.6000	0.6000	NA	NA	NA	0.0	0.5500	0.8000	NONPARAMETRIC	9
RADIUM-228	PCI/L	35	** 0.9000	2.4000	** 0.9000	NA	NA	NA	31.4	** 0.9000	** 0.9000	NONPARAMETRIC	2
REDOX POTENTIAL	mVOLTS	3	300.5000	401.8000	348.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	37	** 0.0050	0.2260	0.0360	NA	NA	NA	16.2	0.0180	0.0660	NONPARAMETRIC	2
SILVER	MG/L	37	** 0.0100	0.0300	** 0.0100	NA	NA	NA	70.3	** 0.0100	0.0100	NONPARAMETRIC	2
SODIUM	MG/L	37	13.0000	1200.0000	250.0000	187.4110	4.7345	NA	0.0	100.5971	349.1438	LOGNORMAL	7,8

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SPECIFIC CONDUCTANCE	UMHO/CM	37	300.0000	7360.0000	2500.0000	2760.0811	2003.5589	0.7259	0.0	1958.3628	3561.7994	NORMAL	
STRONTIUM	MG/L	6	0.5400	3.6900	+ 3.2850	2.5400	1.4340	0.5646	0.0	0.5700	4.5100	NORMAL	
SULFATE	MG/L	37	134.0000	3360.0000	1990.0000	1722.1892	1199.0989	0.6963	0.0	1242.3732	2202.0052	NORMAL	
SULFIDE	MG/L	17	** 0.1000	0.4000	** 0.1000	NA	NA	NA	94.1	** 0.1000	** 0.1000	NONPARAMETRIC	2
TEMPERATURE	C - DEGREE	37	5.0000	19.6000	11.6000	11.3000	2.8454	0.2518	0.0	10.1614	12.4386	NORMAL	
THALLIUM	MG/L	19	** 0.0100	0.0150	** 0.0100	NA	NA	NA	89.5	** 0.0100	0.0100	NONPARAMETRIC	2
THORIUM-230	PCI/L	6	** 0.1000	0.3000	** 0.1000	NA	NA	NA	66.7	** 0.1000	0.3000	NONPARAMETRIC	2,6
TIN	MG/L	17	** 0.0050	0.0680	0.0100	NA	NA	NA	52.9	** 0.0050	0.0250	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS	MG/L	37	468.0000	6560.0000	3440.0000	3308.4865	2265.5718	0.6848	0.0	2401.9245	4215.0485	NORMAL	
TOTAL ORGANIC CARBON	MG/L	2	46.5000	117.0000	+ 81.7500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.5 - FORMER TAILINGS AREA ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR01 DURANGO PROCESSING SITE
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
URANIUM	MG/L	37	** 0.0010	4.6700	0.2010	0.1488	13.1570	NA	5.4	0.0531	0.4173	LOGNORMAL	7,8
VANADIUM	MG/L	20	** 0.0100	0.6100	+ 0.0100	NA	NA	NA	40.0	** 0.0100	0.4900	NONPARAMETRIC	2
ZINC	MG/L	31	** 0.0050	2.8200	0.0870	0.1066	12.1288	NA	9.7	0.0354	0.3205	LOGNORMAL	7,8

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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As stated in Section 3.1.6, four hazardous constituents with no MCLs are considered to be potential groundwater contaminants. These are cobalt, copper, vanadium, and zinc. For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater was compared to the statistical maximum for background groundwater quality (Calculation DUR-01-10-90-14-10-00, Appendix A.) If statistical maxima were unavailable for certain parameters due to less than four samples, comparisons were made with observed background maxima. The statistical maximum for background groundwater quality was exceeded for the hazardous constituents copper, vanadium, and zinc.

The criteria of exceedance of the statistical maximum was used to determine whether copper, vanadium, and zinc should undergo further statistical analysis as they may be considered potential groundwater contaminants. When the proportion of nondetects in the downgradient sample population of a given constituent exceeded 50 percent, but at least 10 percent of the samples were quantitated, a test of proportions was used. When the proportion of nondetects in the downgradient sample population of a given constituent was less than 50 percent the analysis of variance procedure could be used.

The test of proportions was used to evaluate statistically the difference between background and downgradient well sample analyses for the hazardous constituent copper (Calculation DUR-01-10-90-14-11-00, Appendix A). In order to use the test of proportions, a criterion has to be fulfilled regarding the proportion of quantitated values and the total number of samples. In the test of proportions for copper, there was no statistically significant evidence at the five percent significance level that the downgradient wells exceed the proportion of background well samples where copper was detected.

An analysis of variance was used to evaluate statistically the difference between background and downgradient well sample analyses for the hazardous constituents vanadium and zinc (Calculation DUR-01-10-90-14-11-00, Appendix A). There was a difference between the means of the background and downgradient well samples for the constituents vanadium and zinc. Therefore, there is statistical evidence that the hazardous constituents vanadium and zinc are groundwater contaminants related to uranium processing in the former tailings piles area that exceed background water quality.

Groundwater samples collected in 1985 from alluvium monitor well 626 at the processing site were analyzed for priority pollutant organics. No concentrations of organic compounds were detected at levels greater than method detection limits. In January 1990, groundwater samples from monitor wells 617 and 622 were collected and screened for EPA Appendix IX organic compounds. No concentrations of organic compounds from this list were detected at levels greater than method detection limits.

Raffinate ponds

Hazardous constituents with MCLs with concentrations or activities that exceeded the laboratory method detection limits in Menefee Formation and Point Lookout Sandstone monitor wells at the former raffinate ponds area are listed in Table 3.6. These include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, nitrate, net gross alpha, radium-226 and -228, selenium, silver, and uranium. Elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded the laboratory method detection limits include antimony, copper, fluoride, nickel, sulfide, thallium, tin, vanadium, and zinc.

A statistical analysis of groundwater quality in the former raffinate ponds area is presented in Table 3.6. Maximum observed concentrations or activities of eight hazardous constituents equalled or exceeded proposed EPA MCLs in the bedrock groundwater system downgradient of the former raffinate ponds area. These constituents include arsenic, cadmium, chromium, lead, molybdenum, net gross alpha, selenium, and uranium. Concentrations of all of these constituents also exceed laboratory method detection limits in the tailings pore water. Therefore, the presence of these hazardous constituents in groundwater may be related to uranium processing activities.

To confirm whether these excursions represent groundwater contamination, the lower end of the 98 percent confidence interval for these constituents by monitor well was compared with the MCL. According to "Statistical Analyses of Ground-Water Monitoring Data at RCRA Facilities-Interim Final Guidance" (EPA, 1989), if the lower end of the confidence interval exceeds the MCLs, there is statistical evidence of an exceedance of the MCLs. Because the lower end of the confidence interval does not exceed the MCLs for arsenic, cadmium, chromium, lead, molybdenum, net gross alpha, selenium, and uranium, there is no statistical evidence that they are groundwater contaminants with concentrations that exceed the MCLs.

As stated in Section 3.1.6, four hazardous constituents with no MCLs are considered to be potential groundwater contaminants. These are cobalt, copper, vanadium, and zinc. For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater is normally compared to the statistical maximum for background groundwater quality within the same geologic unit. However, there are no background monitor wells completed in bedrock units in the raffinate ponds area. Therefore, maximum observed concentrations in downgradient bedrock groundwater were compared to statistical maxima for groundwater quality within the alluvium/bedrock contact zone monitored by well 607. This is a conservative approach since background concentrations in the alluvium are probably lower than concentrations in the bedrock units given the longer residence times typical for groundwater in bedrock.

If statistical maxima were unavailable for certain parameters due to less than four samples, comparisons were made with observed

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	21	548.0000	925.0000	719.0000	720.9048	135.4839	0.1879	0.0	646.1644	795.6451	NORMAL	
ALUMINUM	MG/L	2	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	4	3.1000	3.7000	+ 3.4000	3.4000	0.2582	0.0759	0.0	2.8138	3.9862	NORMAL	
ANTIMONY	MG/L	6	** 0.0030	0.1660	+ 0.0470	NA	NA	NA	50.0	** 0.0030	0.1660	NONPARAMETRIC	2,6
ARSENIC	MG/L	21	** 0.0100	0.1940	0.0200	NA	NA	NA	47.6	** 0.0100	0.0530	NONPARAMETRIC	2
BARIUM	MG/L	15	** 0.0100	0.0500	0.0500	NA	NA	NA	86.7	0.0100	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	8	** 0.0050	0.0050	+ 0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2
CADMIUM	MG/L	21	** 0.0010	0.0810	0.0025	NA	NA	NA	47.6	** 0.0010	0.0160	NONPARAMETRIC	2
CALCIUM	MG/L	21	53.7000	491.0000	388.0000	321.8429	126.3260	0.3925	0.0	252.1545	391.5312	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	2	20.0000	40.0000	+ 30.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE	MG/L	21	75.0000	2400.0000	1590.0000	1534.7619	615.7261	0.4012	0.0	1195.0936	1874.4302	NORMAL	
CHROMIUM	MG/L	15	** 0.0100	0.1600	** 0.0100	NA	NA	NA	73.3	** 0.0100	0.0700	NONPARAMETRIC	2
COBALT	MG/L	7	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	** 0.0300	** 0.0300	NONPARAMETRIC	2
COPPER	MG/L	15	** 0.0100	0.0200	0.0100	NA	NA	NA	80.0	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	8	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
FLUORIDE	MG/L	15	** 0.1000	0.4000	0.1700	0.1587	0.0880	0.5545	13.3	** 0.1000	0.2183	NORMAL	
GROSS ALPHA	PCI/L	15	** 0.2000	900.0000	109.0000	55.6688	12.2817	NA	13.3	10.1771	304.5092	LOGNORMAL	7,8
GROSS BETA	PCI/L	15	19.0000	360.0000	120.0000	143.0667	98.7526	0.6903	0.0	76.1604	209.9729	NORMAL	
IRON	MG/L	21	** 0.0300	7.8000	0.3400	0.3456	3.1496	NA	4.8	0.1836	0.6509	LOGNORMAL	7,8
LEAD	MG/L	15	** 0.0100	0.0700	0.0200	NA	NA	NA	40.0	** 0.0100	0.0400	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM	MG/L	21	94.0000	724.0000	481.0000	404.9524	208.3340	0.5145	0.0	290.0239	519.8808	NORMAL	
MANGANESE	MG/L	21	0.1700	1.9000	1.3200	1.0381	0.5748	0.5537	0.0	0.7210	1.3552	NORMAL	
MERCURY	MG/L	21	** 0.0002	0.0005	** 0.0002	NA	NA	NA	81.0	** 0.0002	** 0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	21	** 0.0100	0.3800	0.0200	NA	NA	NA	47.6	** 0.0100	0.0900	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	15	-103.1100	392.9100	31.9100	NA	NA	NA	0.0	-34.7700	204.3300	NONPARAMETRIC	9
NICKEL	MG/L	8	** 0.0400	0.0500	** 0.0400	NA	NA	NA	87.5	** 0.0400	0.0500	NONPARAMETRIC	2
NITRATE	MG/L	15	** 1.0000	13.7000	** 1.0000	NA	NA	NA	60.0	** 1.0000	5.2000	NONPARAMETRIC	2
NITRITE	MG/L	1	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRITE AND NITRATE	MG/L	2	0.4500	0.5000	+ 0.4750	NA	NA	NA	50.0	NA	NA	UNKNOWN	1

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
9) The nonparametric distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
PH	SU	21	7.0300	7.6300	7.3600	NA	NA	NA	0.0	NA	NA	UNKNOWN	
POTASSIUM	MG/L	21	8.9000	114.0000	62.1000	56.5095	36.9468	0.6538	0.0	36.1276	76.8914	NORMAL	
RADIUM-226	PCI/L	21	** 0.1000	0.3000	** 0.1000	NA	NA	NA	52.4	** 0.1000	0.2000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	19	0.1000	1.6000	0.5500	0.6711	0.4043	0.6024	0.0	0.4344	0.9077	NORMAL	
RADIUM-228	PCI/L	19	** 0.8000	1.5000	** 0.8000	NA	NA	NA	42.1	** 0.8000	0.9000	NONPARAMETRIC	2
REDOX POTENTIAL	mVOLTS	1	199.7000	199.7000	199.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	21	** 0.0030	0.7630	0.0320	NA	NA	NA	38.1	** 0.0030	0.1110	NONPARAMETRIC	2
SILVER	MG/L	21	** 0.0100	0.0400	** 0.0100	NA	NA	NA	57.1	** 0.0100	0.0200	NONPARAMETRIC	2
SODIUM	MG/L	21	876.0000	5730.0000	3320.0000	3442.7619	1308.7998	0.3802	0.0	2720.7562	4164.7676	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	21	4500.0000	120000.0000	11000.0000	10835.8843	1.9711	NA	0.0	7452.2395	15755.8528	LOGNORMAL	7,8

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
STRONTIUM	MG/L	2	7.0400	11.1000	+ 9.0700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE	MG/L	21	2740.0000	12900.0000	7840.0000	7698.5714	2995.0414	0.3890	0.0	6046.3424	9350.8004	NORMAL	
SULFIDE	MG/L	7	** 0.1000	0.4000	** 0.1000	NA	NA	NA	57.1	** 0.1000	0.4000	NONPARAMETRIC	2
TEMPERATURE	C - DEGREE	21	11.4000	14.2000	12.2000	12.3429	0.6660	0.0540	0.0	11.9754	12.7103	NORMAL	
THALLIUM	MG/L	8	** 0.0100	0.0600	+ 0.0200	NA	NA	NA	25.0	** 0.0100	0.0600	NONPARAMETRIC	2
THORIUM-230	PCI/L	6	** 0.1000	1.2000	+ 0.2500	NA	NA	NA	16.7	** 0.1000	1.2000	NONPARAMETRIC	2,6
TIN	MG/L	7	** 0.0050	0.1990	0.0890	NA	NA	NA	28.6	** 0.0050	0.1990	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS	MG/L	21	4380.0000	21100.0000	15000.0000	14233.3333	5030.2637	0.3534	0.0	11458.3641	17008.3025	NORMAL	
TOTAL ORGANIC CARBON	MG/L	1	57.1000	57.1000	57.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM	MG/L	21	** 0.0010	0.9330	0.0940	0.0480	11.3144	NA	4.8	0.0126	0.1831	LOGNORMAL	7,8

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.6 - FORMER RAFFINATE PITS AREA MONITOR WELLS 602 AND 603, GROUNDWATER QUALITY STATISTICS BY PARAMETER, DURANGO PROCESSING SITE, COLORADO
SITE: DUR02 DURANGO RAFFINATE PITS
04/04/87 TO 08/05/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM	MG/L	8	** 0.0100	0.0700	** 0.0100	NA	NA	NA	50.0	** 0.0100	0.0700	NONPARAMETRIC	2
ZINC	MG/L	15	** 0.0050	0.0210	** 0.0050	NA	NA	NA	66.7	** 0.0050	0.0150	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: M:\DART\DUR02\GWQ10002.DAT

background maxima. The statistical maximum for background groundwater quality was exceeded for the hazardous constituent vanadium.

The criterion of exceedance of the statistical maximum was used to determine whether vanadium should undergo further statistical analysis as it may be considered a potential groundwater contaminant. The test of proportions was used to evaluate statistically the difference between background and downgradient well sample analyses for vanadium (Calculation DUR-01-10-90-14-10-00, Appendix A). In order to use the test of proportions, a criterion has to be fulfilled regarding the proportion of quantitated values and the total number of samples. In the test of proportions for vanadium, there was no statistical significant evidence at the five percent significance level that concentrations in the downgradient wells exceed the proportion of background well samples where vanadium was detected.

Groundwater samples collected in 1985 from monitor wells 602 and 625 were analyzed for priority pollutant organics. Results indicate concentrations of only di-n-butyl-phthalate were above detetion limits (64 and 23 micrograms per liter) in the raffinate ponds area. This compound is a common laboratory contaminant (Vershueren, 1983). There is no existing or proposed drinking water standard for this compound. In January 1990, groundwater samples from monitor well 602 were collected and screened for EPA Appendix IX organic compounds. No organic compounds from this list were detected with concentration levels greater than method detection limits

3.1.8 Groundwater use, value, and alternative supplies

The major water supply for the city of Durango comes from gallery collection systems located in the floodplain alluvium of the Animas River. All of these systems are located upgradient of the tailings piles and raffinate pond areas. The Dakota Sandstone, a regional aquifer, is locally used for stock watering.

The Mancos Shale, which underlies the former tailings piles, is not an aquifer in the area. The Menefee Formation, which underlies the former raffinate ponds, is not widely used as a source of groundwater in the Durango area. There are no water supply wells in the immediate vicinity of the raffinate ponds area. The closest downgradient private wells are approximately two miles south and southeast of the site according to state well permit records. Natural water quality within the Menefee water-bearing strata (shales, sandstones, and coal beds) is poor, with concentrations of iron, manganese, sulfate, and TDS often in excess of National Secondary Drinking Water Standards. The DOE monitor wells in the Bodo Canyon area (i.e., background wells) confirm elevated levels of these constituents associated with Menefee Formation shale and coal beds (DOE, 1986a).

Reported well yields from the Menefee are as high as 10 gallons per minute in central La Plata County. The most transmissive strata of the Menefee Formation are probably the coal seams or bedding planes separating coal, shale, and sandstone interbeds. Groundwater associated with coal seams, shales, or shaley sandstones, or at depths below these strata, is of poor quality. Therefore, both the present and future value of the Menefee Formation as a groundwater supply for domestic or industrial purposes is marginal. However, its potential value is greater for livestock watering or irrigation. Present and projected land use in the area downgradient (southeast) of the raffinate ponds area is largely commercial and industrial (DOE, 1984a). The Animas River most likely acts as a natural hydraulic barrier to alluvial groundwater flow between the Durango processing site and the areas east of the river.

The present availability of alternative water supplies in the area is good. The city of Durango utilizes water from the Animas and Florida Rivers to supply the Lemon Reservoir, which has a 75.6-million-gallon capacity. The city's pumping system has a rated capacity of approximately 7.8 million gallons per day (mgd) and a treatment system capacity of 12 mgd. Average daily demand on the city's water supply system ranges from three to 10 mgd, and the city pumps water from the Animas River upstream of the former tailings area to supplement storage in the reservoir during peak demand summer months (DOE, 1984a).

Drinking water in the Durango area is supplied by the City Water Utility and by three nearby water companies. The City Water Utility serves the area within the city limits and 1.5 miles eastward along Florida Road (Peevey, 1990; Maestas, 1989). Water in adjacent areas is supplied by 1) the Animas Water Company, which serves the Animas River valley northward to Baker's Bridge; 2) the South Durango Water District, which serves the Animas River Valley southward for 2.5 miles and west about one mile along U.S. Highway 160; and 3) wells in the Rafter J subdivision northwest of the Bodo Canyon disposal site (Hock, 1989; Black and Veatch, 1981). Both water districts buy all of their water supplies directly from the City Water Utility. The Rafter J subdivision relied on a series of deep wells for potable water, but recently also began buying water from the City Water Utility when its wells began to run dry (Maestas, 1989). All other residents in the area are supplied by private wells.

The City Water Utility diverts raw water from the Florida and Animas Rivers, using its direct flow rights and storage decrees for both river systems. Neither the utility nor the two water companies owns or operates any other wells or other water sources. The city has approximately 4,000 metered customers, the Animas Water Company serves 476, and the South Durango Water District serves about 150 (Miller, 1990; Peevey, 1990; Turner, 1990). The city sells water for $11.20 for the first 4,000 gallons, and $0.88 per thousand gallons thereafter. The Animas Water Company charges a $10 minimum,

and $1.85 per thousand gallons used. The South Durango Water District charges $16 per three thousand gallons. No current information is available on the exact number of the Rafter J subdivision water users or their water rates, but it is estimated that the subdivision contains several hundred residences. The value of groundwater that could be developed in the vicinity of the Durango site would be at least equal to the cost of the city water.

The present water resources available to the area meet current and projected needs, particularly as the population has not grown as predicted in the early 1980s (Maestas, 1989; Black and Veatch, 1981). The city also has additional (average annual 8,200 acre-feet) municipal and industrial water allocated from the Bureau of Reclamation's proposed Animas-La Plata Project for future development. This water would be accessed either from the proposed Ridges Basin Inlet Conduit on the Animas River, from the proposed Ridges Basin Reservoir west of the Bodo Canyon disposal site, or from the city's existing Durango Pumping Plant on the river. Thus, development of groundwater in the Durango site area was determined to be not cost-effective and has been dropped as a viable water source alternative when compared to other readily available sources (Black and Veatch, 1981).

Because the city has a high-quality water distribution system in place, it could be readily expanded to serve the water supply needs of any new developments in the vicinity of contaminated groundwater near the former Durango processing site. Potential deeper aquifers that could provide water to new residents in the vicinity include the Dakota Sandstone and Morrison Formation, with reported well yields as high as 25 gallons per minute (Brogden and Giles, 1976). The Point Lookout Sandstone has not been widely tapped, and its value as a potential alternative water supply source is unknown.

3.2 DISPOSAL SITE

3.2.1 Previous investigations

Hydrogeologic investigations began in Bodo Canyon in 1983 during the course of the tailings disposal site selection process. During the process of disposal site characterization and selection, test pits, piezometers, test borings, and monitor wells were installed in Bodo Canyon. Dames and Moore (1983) initiated a geotechnical and hydrogeologic study of the Bodo Canyon site, which included the drilling of 12 boreholes and the excavation of two soil test pits. Four monitor wells and eight piezometers were installed at the site by Dames and Moore. In 1984, the DOE installed four monitor wells in the area of the planned disposal cell footprint. Corehole logging, packer testing, slug testing, soil sampling and testing, and groundwater sampling and analysis were also performed. Data on soil characteristics, bedrock lithology, hydraulic conductivity, and water quality from these field investigations were analyzed in order to characterize the hydrogeochemical environment

beneath Bodo Canyon and to assess its suitability for a tailings disposal site. This information can be found in the DOE's Remedial Action Plan for the Durango site (DOE, 1986a). The location of these wells, piezometers, and borings is shown on Figure 3.6.

The hydrogeology of the disposal site area was reported by the DOE in a Final Environmental Impact Statement (DOE, 1986b) and in a Remedial Action Plan (DOE, 1986a). Selected information from all of these documents was used in writing this report.

3.2.2 Geology and hydrostratigraphy

A summary of the geology of the disposal site area is presented in this section. For detailed information, refer to Attachment 2 of this report.

At the Bodo Canyon disposal site, the shallowest geologic unit consists of as much as 65 feet of unconsolidated Quaternary alluvial and colluvial deposits made up of silty clay and silt soils that are locally interbedded with layers of mixed sandstone and shale bedrock fragments (hereafter referred to as alluvium). The alluvium generally can be classified (in the Unified Soils Classification System) as varying between low-plasticity silts and clays with some sand. The alluvium mostly overlies the Cliff House Formation, but in the northeast area of Bodo Canyon, an alluvium-filled paleochannel cuts into the Menefee Formation. The thickest areas of the alluvial deposits occur along a subsurface paleochannel feature carved into the underlying bedrock (Figure 3.7).

The Bodo Canyon alluvium is underlain by (in descending order) the Cliff House Sandstone, the Menefee Formation, siltstones and shales, and the Point Lookout Sandstone. The Cliff House, Menefee, and Point Lookout Formations are more generally referred to as the Mesaverde Formation, and immediately underlie the Bodo Canyon disposal site with the Cliff House Sandstone being nearest the surface. The similarity of the Cliff House and Menefee Formations and discontinuous lenses of sandstone, shales, and coal have made definition of the exact contact difficult. The dip and location of the Cliff House/Menefee contact has been estimated from borehole lithology and published geologic maps (Figure 3.8). See Attachment 2 for a more detailed description of the determination of the contact and dip. Bedrock units dip approximately 9.5 degrees to the southeast.

The Menefee Formation ranges from 250 to 350 feet in thickness and contains the major coal beds that occur in the Durango area. The 200- to 400-foot-thick Cliff House Sandstone, overlying the Menefee, consists of interbedded calcareous sandstone, siltstone, and silty shale. Although the Cliff House and Menefee Formations are stratigraphically distinct, there is no significant hydraulic distinction between the two formations and they behave as one hydrogeological unit. Geologic cross sections have been constructed for the Bodo Canyon disposal site and are presented in Figures 3.9, 3.10, and 3.11.

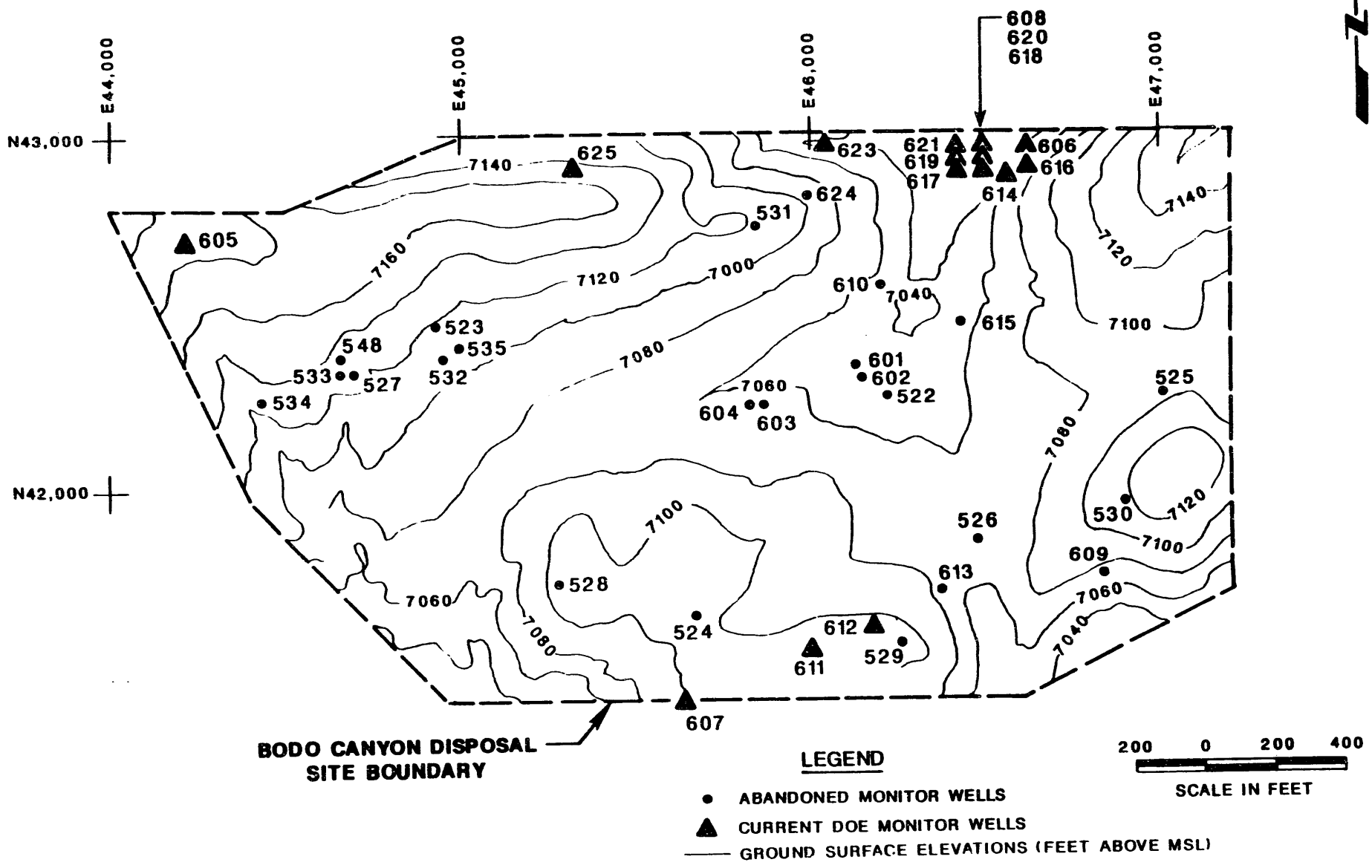


FIGURE 3.6
LOCATION OF MONITOR WELLS AND TOPOGRAPHIC MAP
BODO CANYON DISPOSAL SITE, COLORADO

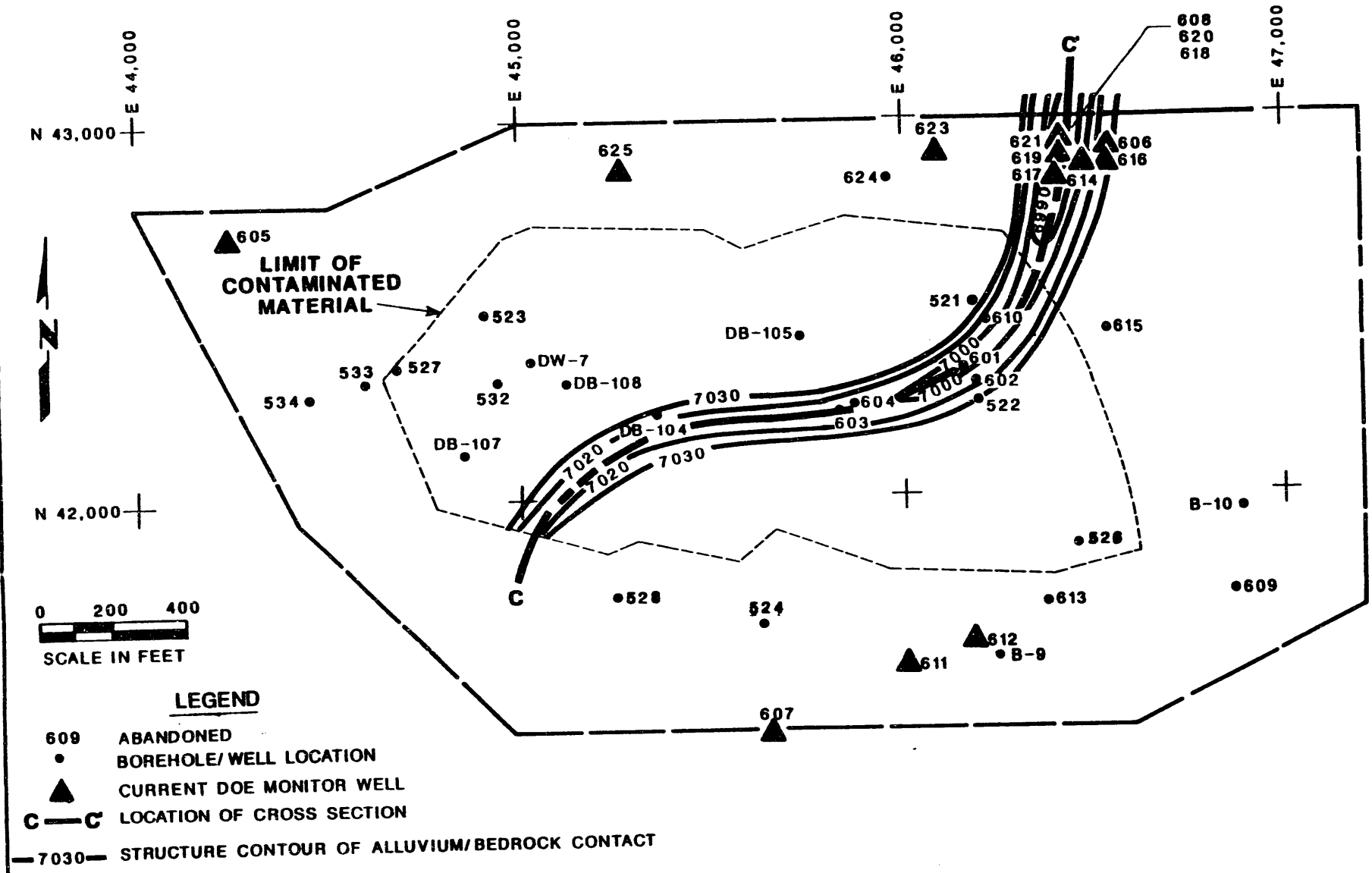


FIGURE 3.7
PALEOCHANNEL ALIGNMENT BELOW CELL AREA, EXISTING DOE MONITOR WELLS, AND LOCATION OF CROSS SECTION C-C' BODO CANYON DISPOSAL SITE, COLORADO

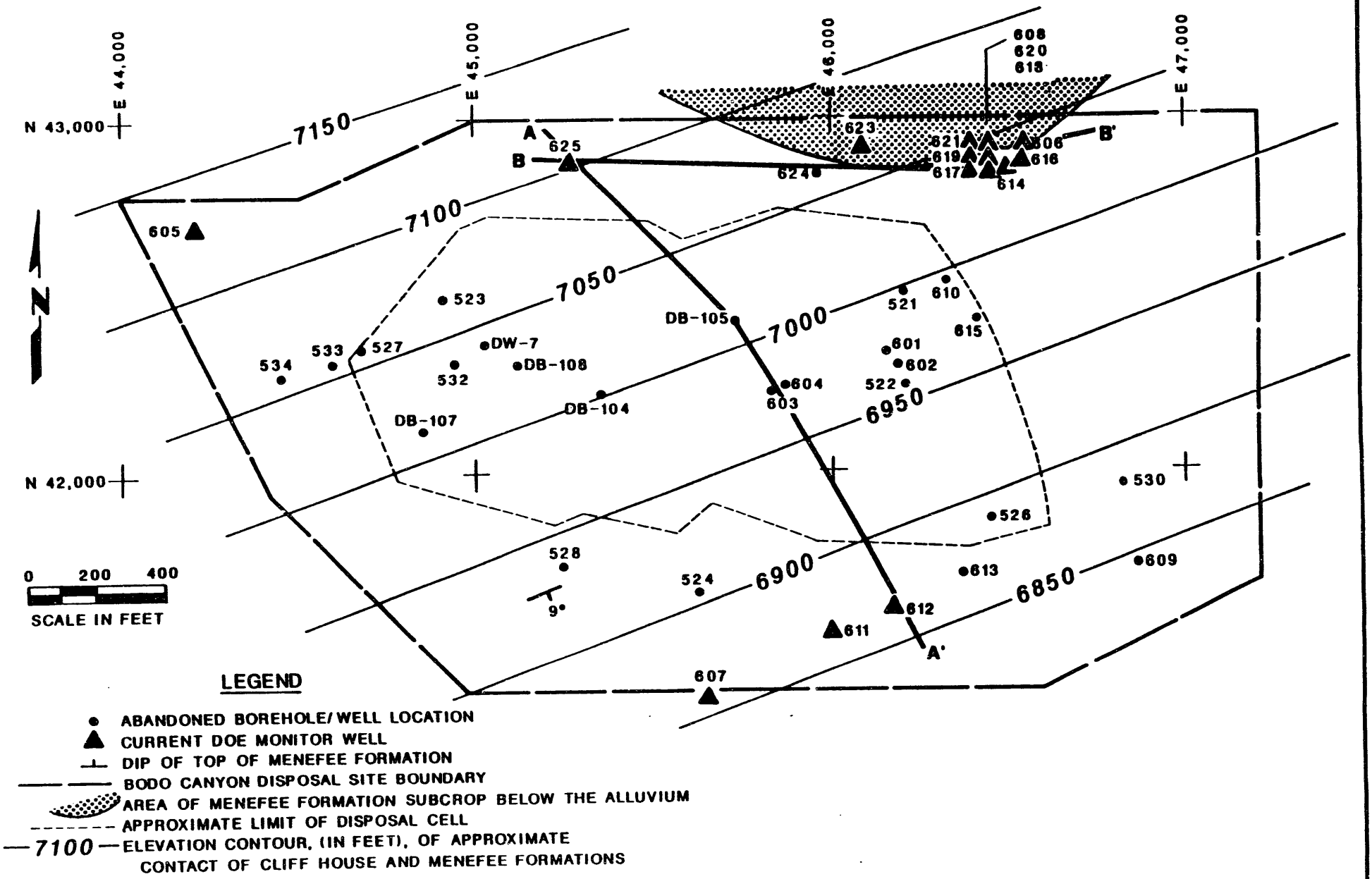
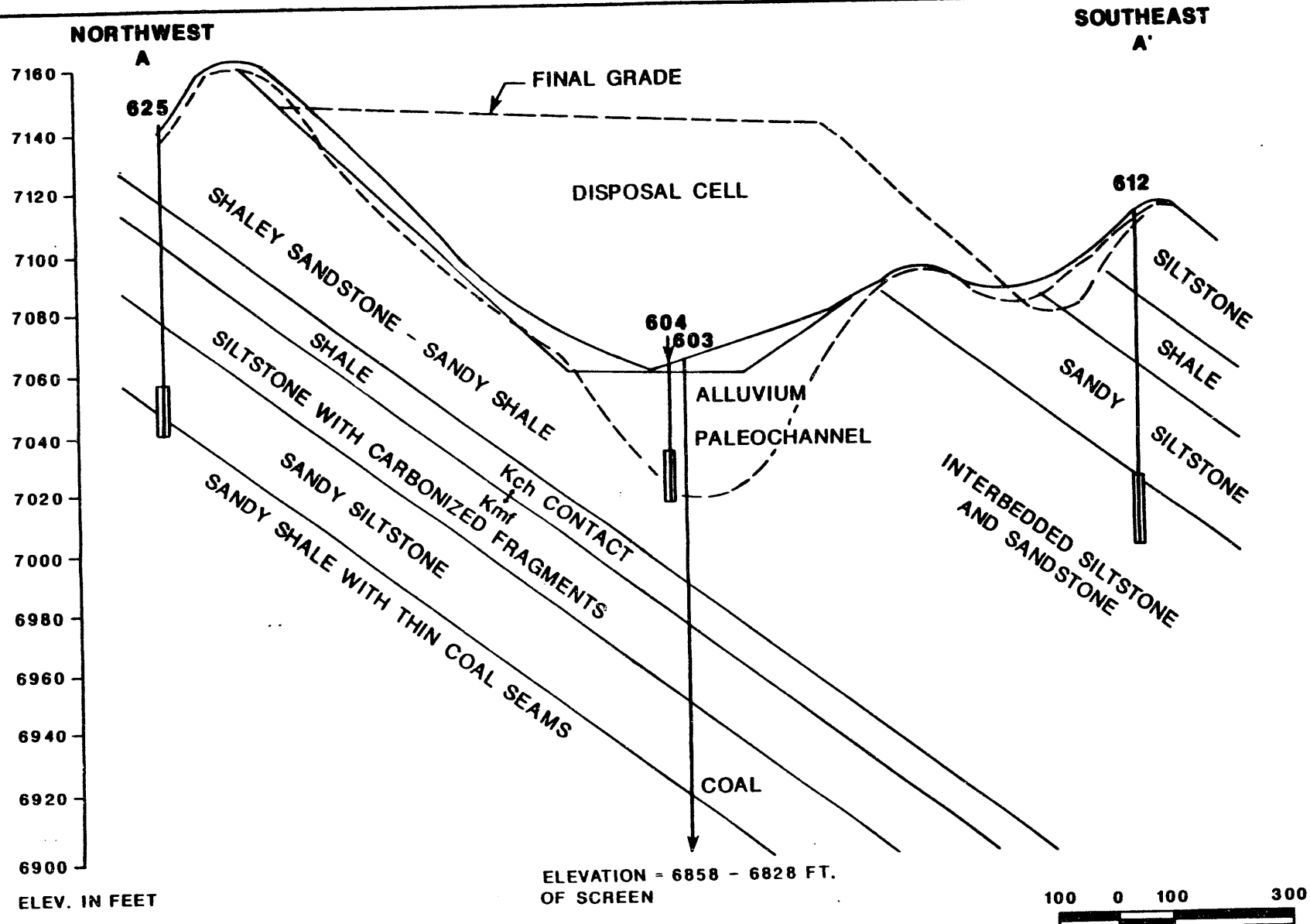


FIGURE 3.8
CROSS SECTION LOCATIONS AND STRUCTURAL CONTOUR OF TOP OF MENEFEE FORMATION BODO CANYON DISPOSAL SITE, COLORADO

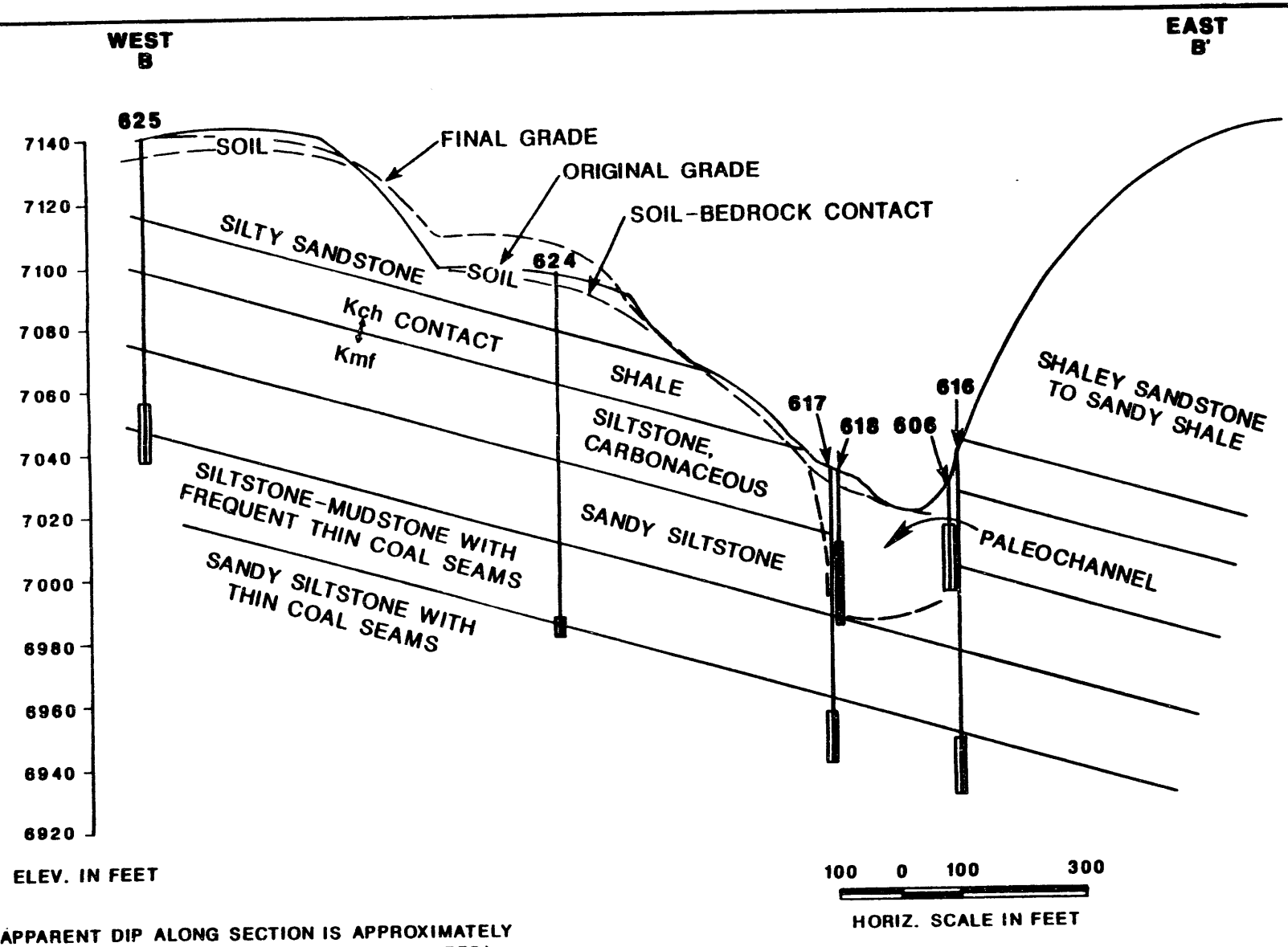


NOTES: APPARENT DIP ALONG SECTION IS APPROXIMATELY 8.5 DEGREES (TRUE DIP IS ABOUT 9.5 DEGREES)

LOCATION OF THIS CROSS SECTION IS SHOWN ON FIGURE 3.8

Kch = CLIFFHOUSE FORMATION
Kmf = MENEFEE FORMATION

FIGURE 3.9
SCHEMATIC CROSS SECTION A-A'
BODO CANYON DISPOSAL SITE, COLORADO



NOTES: APPARENT DIP ALONG SECTION IS APPROXIMATELY 3.3 DEGREES (TRUE DIP IS ABOUT 9.5 DEGREES)

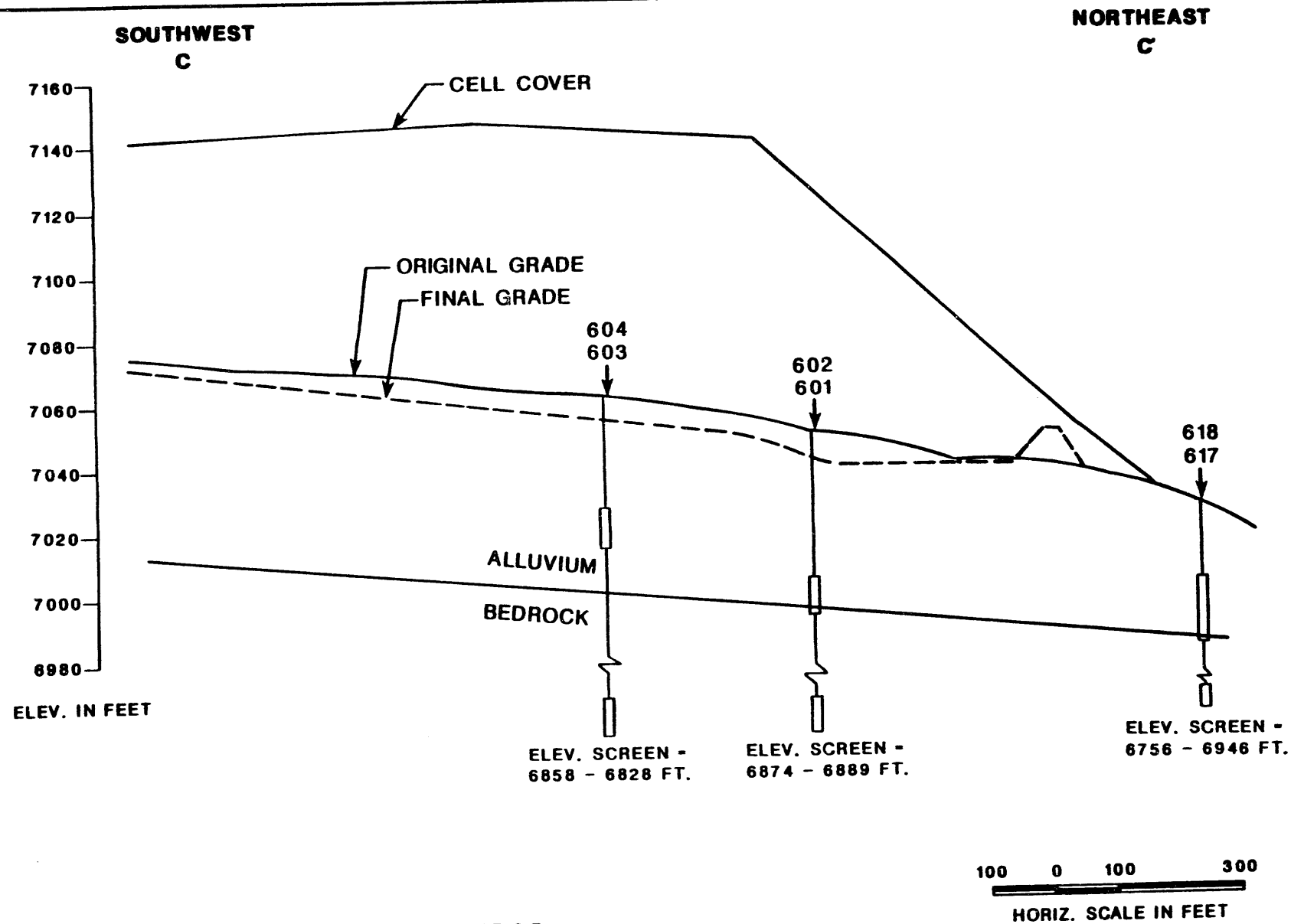
LOCATION OF THIS CROSS SECTION IS SHOWN ON FIGURE 3.8

LEGEND

Kch - CLIFFHOUSE FORMATION

Kmf - MENEFEE FORMATION

FIGURE 3.10
SCHEMATIC CROSS SECTION B-B'
BODO CANYON DISPOSAL SITE, COLORADO



NOTE: CROSS SECTION LOCATION IS SHOWN ON FIGURE 3.7

FIGURE 3.11
SCHEMATIC CROSS SECTION C-C'
BODO CANYON DISPOSAL SITE, COLORADO

Hydrogeologically, the stratigraphy at Bodo Canyon can be divided into two zones:

1) A surficial layer of alluvium consisting of silty clay and silt soils locally interbedded with bedrock fragments. These deposits vary in thickness from one to 65 feet.

2) The Cliff House and Menefee Formations, referred to as the Cliff House/Menefee aquifer, which consists of a continuous sequence of interbedded sandstones, shales, and coal. These units extend to a depth of several hundred feet below the disposal site.

3.2.3 Presence and movement of groundwater

The DOE wells completed in the alluvium include well numbers 601, 604, 606, 608, 614, 615, 618, 620, and 623 (Figure 3.6 and Table 3.7). Monitor well 623 is located in an alluvial system in an adjacent canyon to the north of the Bodo Canyon alluvium. Table 3.7 provides monitoring well construction data for the DOE wells in Bodo Canyon. Currently, six wells exist in Bodo Canyon that are completed in the alluvium. Monitor wells 601 and 604 were abandoned when disposal cell construction began in 1987 since they were located within the cell footprint.

Shallow groundwater occurs within the alluvium at depths that range seasonally from approximately 20 to 50 feet below the surface. Saturation in the alluvium occurs primarily in the northeastern area of Bodo Canyon along the central axis of the paleochannel. Seasonal hydrographic data collected from Dames & Moore piezometers completed in the alluvium indicate that during periods of peak recharge, the direction of groundwater flow is generally to the northeast down the axis of Bodo Canyon. However, during periods of the year when recharge is low, the gradient seems to reverse and groundwater flow is to the center of the basin. The implication is that baseflow from Bodo Canyon to the arroyo to the northeast is seasonal. This assumption is based on observed fluctuations in the potentiometric surface in the Dames & Moore wells (Dames & Moore, 1983).

Table 3.8 provides a list of water levels recorded in the DOE alluvium monitor wells at the Bodo Canyon disposal site. Prior to disposal cell construction, water levels in the alluvium were monitored with DOE monitor wells 601 and 604. A hydrograph of the saturated thickness of the alluvial system for these monitor wells is presented in Figure 3.12. Both of these wells are located along the axis of the paleochannel. Figure 3.12 shows a constant saturation of the alluvium in the area of monitor well 601, yet no saturation in the area of monitor well 604 for most of the 1985 monitoring year. The precipitation recorded for 1985 is 92 percent of normal. The rise in water level in November 1985 is probably due to the 7.42 inches of precipitation received from September through November 1985. However, in the period January through April 1985, 5.82 inches of precipitation occurred and no increase in saturated thickness resulted.

TABLE 3.7 - MONITOR WELL INFORMATION, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
REPORT DATE: 09/27/90

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT) *	CASING STICKUP (FT)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT) *	CASING + DIAMETER (INCHES)	SCREEN * BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0200	042450.0	046250.0	-	035.00	-	-	36.50	4.000	15.00	20.0	O	TA
0201	42410.0	46125.0	-	55.60	-	-	61.00	4.500	50.00	10.0	O	TA
0202	42335.0	46000.0	-	47.50	-	-	51.00	4.000	40.00	10.0	O	TA
0203	-	-	-	50.50	-	-	56.00	4.000	45.00	10.0	O	TA
0204	42300.0	45650.0	-	42.50	-	-	46.00	4.500	55.00	10.0	O	TA
0521	42520.0	46190.0	7050.00	86.50	-0.18	7049.82	84.50	2.000	-	15.0	N	SH
0522	42270.0	46205.0	7052.00	93.50	3.89	7055.89	95.65	2.000	-	20.0	N	SH
0523	42480.0	44900.0	7122.00	63.00	-6.00	7116.00	63.00	2.000	-	20.0	N	NR
0524	41620.0	45640.0	7105.00	122.80	2.49	7107.49	123.05	2.000	102.80	20.0	N	SH
0525	42265.0	46980.0	7095.00	121.00	-0.30	7094.70	121.00	2.000	101.00	20.0	N	SH
0526	41825.0	46465.0	7071.00	100.00	-0.30	7070.70	102.60	2.000	85.00	15.0	N	SS
0527	42350.0	44670.0	7130.00	40.00	-	-	-	-	-	-	N	NR
0528	41715.0	45250.0	7103.00	40.00	3.69	7106.69	40.00	2.000	25.80	14.2	N	SH
0529	41540.0	46245.0	7110.00	41.00	-	-	-	-	-	-	N	NR
0530	41930.0	46890.0	7115.00	35.00	-	-	-	-	-	-	N	NR
0531	42745.0	45820.0	7121.00	50.00	-	-	-	-	-	-	N	NR
0532	42380.9	44917.4	7061.45	44.00	0.67	7062.12	44.67	4.000	13.50	30.5	N	NR
0533	42327.6	44623.9	7053.19	64.00	0.50	7053.69	64.50	4.000	33.80	30.2	N	NR
0534	42271.2	44423.3	7061.18	69.50	1.70	7062.88	70.20	4.000	28.90	40.1	N	NR
0535	42396.7	44954.7	7060.14	200.00	1.00	7061.14	193.00	4.000	62.00	-	N	NR
0543	42137.7	43882.9	-	33.00	-	-	33.00	2.000	23.00	10.0	N	NR
0548	42362.6	44642.6	7054.00	64.00	-	-	-	-	-	-	N	NR
0601	42340.0	46120.0	7048.00	52.00	2.04	7050.04	52.80	2.000	-	10.0	N	ML
0602	42310.0	46135.0	7049.00	192.00	0.66	7049.66	192.00	2.000	-	15.0	N	SH
0603	42240.0	45830.0	7058.00	255.00	4.85	7062.85	199.00	2.000	-	30.0	N	SH
0604	42245.0	45800.0	7058.00	45.00	6.54	7064.54	46.00	2.000	32.00	10.0	N	ML
0605	42693.8	44216.4	7187.60	60.80	2.00	7189.60	61.00	4.000	38.00	20.0	U	CF
0606	42899.9	46538.4	7034.10	38.00	2.40	7036.50	39.40	4.000	16.00	20.0	D	AL
0607	41375.0	45623.4	7097.10	61.00	2.00	7099.10	61.70	4.000	38.70	20.0	N	CF
0608	42879.1	46374.2	7033.00	45.00	2.00	7035.00	44.00	4.000	31.00	10.0	D	AL
0609	41726.5	46824.3	7075.60	196.00	2.00	7077.60	179.00	4.000	146.00	30.0	N	CF
0610	42560.0	46360.0	-	30.00	-	-	31.50	4.500	20.50	10.0	D	AL
0611	41542.9	45994.8	7109.67	120.50	1.64	7111.31	122.00	4.000	110.00	10.0	D	CF
0612	41595.3	46165.7	7107.89	111.00	1.91	7109.80	112.00	4.000	100.00	10.0	D	CF
0613	41706.3	46369.8	7073.90	82.00	1.10	7075.00	82.00	4.000	70.00	10.0	D	CF

* DEPTH GIVEN IN FEET BELOW GROUND SURFACE

\+ CASING DIAMETER = INSIDE DIAMETER

FORMATION OF COMPLETION CODE:
TA - URANIUM MILL TAILINGS
SH - SHALE
NR - NO RECOVERY OF DATA FOR CLASSIFYING
SS - SANDSTONE
ML - SILTS, SANDY OR GRAVELLY SILTS, DIATOMACEOUS SOILS
CF - CLIFF HOUSE FORMATION
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
O - ON-SITE
N - UNKNOWN
U - UPGRADIENT
D - DOWN GRADIENT

TABLE 3.7 - MONITOR WELL INFORMATION, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
REPORT DATE: 09/27/90

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	GROUND ELEVATION (FT MSL)	BOREHOLE DEPTH (FT) *	CASING STICKUP (FT)	CASING ELEVATION (FT MSL)	CASING DEPTH (FT) *	CASING + DIAMETER (INCHES)	SCREEN * BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	FLOW CODE	FORMATION OF COMPLETION
0614	42854.7	46445.6	7030.53	45.00	1.68	7032.21	46.00	4.000	24.00	20.0	D	AL
0615	42441.3	46419.7	7054.20	51.50	1.56	7055.76	52.00	4.000	40.00	10.0	D	AL
0616	42890.1	46548.9	7028.36	100.50	1.37	7029.73	102.00	4.000	90.00	10.0	U	CF
0617	42860.4	46359.8	7036.19	92.00	-0.08	7036.11	92.00	4.000	80.00	10.0	U	CF
0618	42859.6	46369.6	7034.68	52.50	1.73	7036.41	53.50	4.000	31.50	20.0	D	AL
0619	42870.9	46358.1	7035.02	93.00	1.25	7036.27	92.00	4.000	80.00	10.0	U	CF
0620	42870.1	46371.3	7033.33	51.00	1.06	7034.39	52.00	4.000	30.00	20.0	D	AL
0621	42876.7	46365.2	7034.23	90.00	1.54	7035.77	92.00	4.000	80.00	10.0	U	CF
0623	42944.3	46064.6	7048.67	43.50	-	-	43.00	4.000	21.00	20.0	U	AL
0624	42818.6	45987.1	7094.50	102.00	1.52	7096.02	102.00	4.000	90.00	10.0	U	CF
0625	42917.7	45308.3	7139.62	102.00	1.40	7141.02	102.00	4.000	90.00	10.0	U	CF

* DEPTH GIVEN IN FEET BELOW GROUND SURFACE

+ CASING DIAMETER = INSIDE DIAMETER

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM
CF - CLIFF HOUSE FORMATION

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

DATA FILE: J:\DART\DUR03\MWI10006.DAT

FIELDS DISPLAYED WITH A DASH INDICATE THE DATA IS UNAVAILABLE

TABLE 3.8 - STATIC GROUNDWATER LEVELS: ALLUVIAL MONITOR WELLS, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
REPORT DATE: 12/16/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	LOG DATE	DEPTH FROM TOP OF CASING (FT)	GROUNDWATER ELEVATION (FT MSL)
0601	42340.0	46120.0	ML	N	7050.04	-	10.0	02/17/85	35.00	7015.04
								03/14/85	33.66	7016.38
								04/15/85	26.80	7023.24
								05/15/85	27.20	7022.84
								06/15/85	27.40	7022.64
								07/15/85	28.00	7022.04
								08/15/85	28.40	7021.64
								09/15/85	29.10	7020.94
								10/19/85	29.70	7020.34
								11/16/85	30.20	7019.84
								12/14/85	30.70	7019.34
								04/01/87	24.00	7026.04
0604	42245.0	45800.0	ML	N	7064.54	32.00	10.0	02/17/85	DRY	-
								03/14/85	DRY	-
								04/15/85	DRY	-
								05/15/85	DRY	-
								06/15/85	DRY	-
								07/15/85	DRY	-
								08/15/85	DRY	-
								09/15/85	DRY	-
								10/19/85	DRY	-
								11/16/85	43.60	7020.94
								12/14/85	DRY	-
								04/01/87	DRY	-
0606	42899.9	46538.4	AL	D	7036.50	16.00	20.0	11/20/87	25.27	7011.23
								04/07/88	20.79	7015.71
								06/30/88	22.82	7013.68
								10/07/88	24.97	7011.53
								01/08/89	32.82	7003.68
								04/05/89	26.40	7010.10
								07/13/89	24.67	7011.83
								10/27/89	33.50	7003.00
								11/16/89	34.97	7001.53
								01/06/90	37.50	6999.00
								02/23/90	DRY	-
								05/09/90	36.09	7000.41
								06/25/90	DRY	-
								07/19/90	35.90	7000.60
								08/31/90	DRY	-

FORMATION OF COMPLETION CODE:
ML - SILTS, SANDY OR GRAVELLY SILTS, DIATOMACEOUS SOILS
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
N - UNKNOWN
D - DOWN GRADIENT

TABLE 3.8 - STATIC GROUNDWATER LEVELS: ALLUVIAL MONITOR WELLS, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
REPORT DATE: 12/16/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	LOG DATE	DEPTH FROM TOP OF CASING (FT)	GROUNDWATER ELEVATION (FT MSL)
0606	42899.9	46538.4	AL	D	7036.50	16.00	20.0	09/19/90	36.10	7000.40
								10/28/90	36.16	7000.34
								04/25/91	22.91	7013.59
								08/08/91	26.31	7010.19
0608	42879.1	46374.2	AL	D	7035.00	31.00	10.0	11/20/87	33.33	7001.67
								04/07/88	29.59	7005.41
								06/30/88	31.12	7003.88
								10/07/88	35.26	6999.74
								01/08/89	36.48	6998.52
								04/05/89	34.19	7000.81
								07/13/89	36.89	6996.11
								10/26/89	37.92	6997.08
								11/16/89	37.91	6997.09
								01/05/90	42.07	6992.93
								02/23/90	38.60	6996.40
								05/08/90	38.81	6996.19
								06/25/90	38.95	6996.05
								08/31/90	38.98	6996.02
								09/19/90	39.00	6996.00
								10/29/90	36.25	6998.75
								04/23/91	29.24	7005.76
								08/08/91	36.30	6998.70
0614	42854.7	46445.6	AL	D	7032.21	24.00	20.0	10/26/89	34.33	6997.88
								11/17/89	34.07	6998.14
								05/09/90	35.18	6997.03
								06/25/90	35.30	6996.91
								07/10/90	35.18	6997.03
								08/31/90	35.05	6997.16
								09/19/90	33.25	6998.96
								10/28/90	32.45	6999.76
								04/23/91	27.27	7004.94
								08/08/91	33.06	6999.15
0615	42441.3	46419.7	AL	D	7055.76	40.00	10.0	10/25/89	49.92	7005.84
								11/18/89	48.91	7006.85
								01/07/90	50.62	7005.14
								04/05/90	51.37	7004.39
0618	42859.6	46369.6	AL	D	7036.41	31.50	20.0	10/26/89	40.00	6996.41
								07/17/90	40.80	6995.61

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

TABLE 3.8 - STATIC GROUNDWATER LEVELS: ALLUVIAL MONITOR WELLS, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
REPORT DATE: 12/16/91

LOCATION ID	NORTH COORDINATE (FT)	EAST COORDINATE (FT)	FORMATION OF COMPLETION	FLOW CODE	CASING ELEVATION (FT MSL)	SCREEN BEGINNING DEPTH (FT)	SCREEN LENGTH (FT)	LOG DATE	DEPTH FROM TOP OF CASING (FT)	GROUNDWATER ELEVATION (FT MSL)
0618	42859.6	46369.6	AL	D	7036.41	31.50	20.0	08/31/90	41.07	6995.34
								09/19/90	39.95	6996.46
0620	42870.1	46371.3	AL	D	7034.39	30.00	20.0	10/26/89	38.00	6996.39
								07/17/90	38.83	6995.56
								08/31/90	39.02	6995.37
0623	42944.3	46064.6	AL	U	7048.67	21.00	20.0	10/27/89	34.92	7013.75
								11/17/89	34.29	7014.38
								01/06/90	33.70	7014.97
								02/24/90	34.07	7014.60
								04/27/90	34.05	7014.62
								06/25/90	33.83	7014.84
								07/19/90	33.92	7014.75
								08/31/90	34.77	7013.90
								09/20/90	35.65	7013.02
								10/29/90	34.51	7014.16
								04/25/91	32.10	7016.57
								06/07/91	34.01	7014.66

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

DATA FILE: M:\DART\DUR03\GWL10000.DAT

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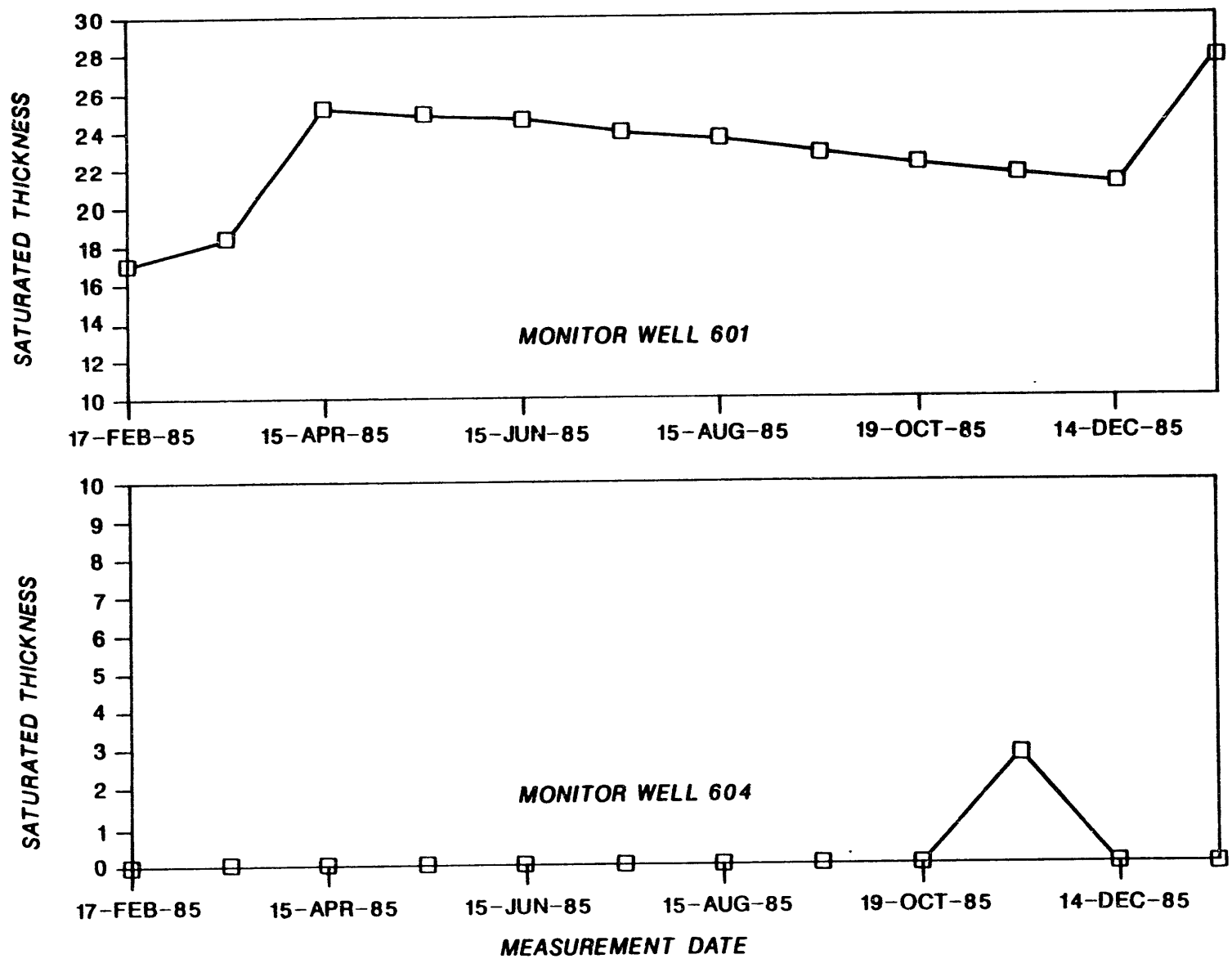

FIGURE 3.12
HYDROGRAPH OF THE SATURATED THICKNESS OF THE ALLUVIUM
BODO CANYON DISPOSAL SITE, COLORADO

Of the 12 boreholes drilled by Dames & Moore in 1983 (Dames & Moore, 1983) in Bodo Canyon, only three (521, 522, and AH-8) encountered water above the bedrock. These three boreholes are located in the northeast area of Bodo Canyon as shown in Figure 3.6. The limited occurrence of shallow groundwater in the Dames and Moore boreholes and in the 601/604 monitor wells provides evidence that alluvium saturation in the mid to upgradient areas of Bodo Basin is infrequent. These observations suggest that under pre-construction natural conditions, there is a large area of the alluvium that is not saturated most of the time. This condition may be due to differences in lithology or surface recharge distribution.

Once disposal cell construction began in 1987, an alteration of natural recharge to the alluvium was affected since the cell footprint covers most of the alluvial system within the paleochannel (Figure 3.10). The Cliff House Formation forms ridges on the north, east, and south sides of the disposal site (Figures 3.8 and 3.9). The bedrock is very shallow at these topographically high areas and covered with soil. The thickness of the alluvium and colluvium decreases to zero approaching these topographically high areas. The drainage divide of Bodo Basin, the total area inside this drainage divide, and the percentage of this area covered by the disposal cell have been determined in calculation (DUR03-05-91-13-01-00). The disposal cell covers 85 percent of the Bodo Basin drainage divide area.

A determination of the change in recharge to the alluvium in response to disposal cell construction was estimated in calculation DUR03-05-91-12-01-00. This was accomplished by comparing an estimated natural precipitation recharge rate and the estimated disposal cell liner transient seepage rate (in acre-feet/year). This calculation shows that recharge to the alluvium will decrease from approximately five acre-feet/year to approximately 0.5 acre-feet/year. This ten-fold decrease in recharge under transient conditions will cause a decrease in alluvial saturation in previously-saturated areas beneath the disposal cell. Under steady-state conditions where just infiltration through the disposal cell cover is of concern, the rate of recharge to the alluvium will decrease by a factor of 50 (Calculation DUR03-05-91-12-01-00). This indicates desaturation of the alluvium beneath the disposal cell will likely occur in response to diminishing recharge caused by the disposal cell. The alluvium beneath the disposal cell is expected to become unsaturated with time.

Figure 3.13 shows hydrographs of saturated thickness in the alluvium northeast of the disposal cell since 1987. This figure shows that water levels in the alluvium northeast of the disposal cell, in the area of monitor well 608, will continue to be influenced by underflow from the adjacent basin north of Bodo Basin and from precipitation and snowmelt runoff from the northeastern half of the disposal cell that can infiltrate in the vicinity of the surface water drainage energy diffusion structure. The increase in water levels during October 1990 reflects the completion of

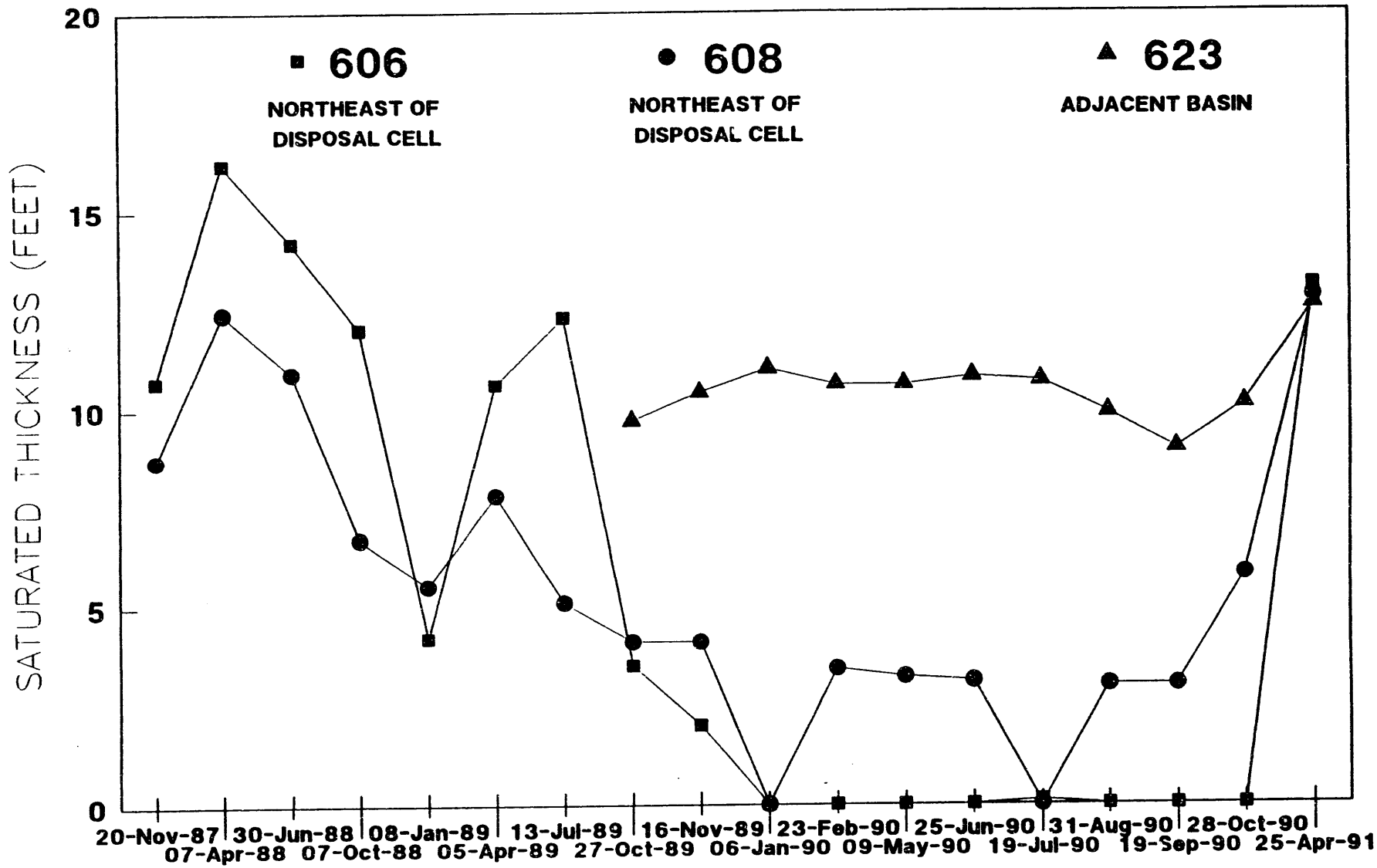

FIGURE 3.13
SATURATED THICKNESS OF THE ALLUVIUM NORTHEAST OF THE DISPOSAL CELL
BODO CANYON DISPOSAL, COLORADO

diversion of surface water runoff ditches that allow runoff to infiltrate in this area of the alluvium. Therefore, this area of the alluvium will not desaturate. Only areas beneath the disposal cell (85 percent of Bodo Basin) are expected to desaturate under steady-state conditions. Because of the limited area of alluvial system saturation under natural conditions, and the desaturation expected in the alluvium beneath the disposal cell, the Cliff House/Menefee aquifer is the uppermost aquifer at the Bodo Canyon site.

Groundwater occurs in the Cliff House Sandstone and the Menefee Formation (Cliff House/Menefee aquifer) beneath the disposal site. These formations outcrop and subcrop in the vicinity of the disposal site and dip approximately 9.5 degrees to the south southeast. Figure 3.8 shows the dip of the contact between the Cliff House and Menefee Formations as constructed by outcrop information and well log information. Several monitor wells were installed in these formations during the disposal site investigations. The DOE monitor wells completed within the bedrock include 602, 603, 605, 607, 609, 611, 612, 616, 617, 619, 621, 624, and 625 (Figure 3.6). Monitor wells 602 and 603 were within the disposal cell footprint and were abandoned in 1987 when disposal cell construction began. Monitor wells 609 and 624 were abandoned in 1990 due to disposal cell construction activities around the perimeter of the cell. Construction data for these wells are presented in Table 3.7.

Monitor wells at the disposal site were completed in a variety of lithologies at varying depths below the surface. Due to the different field investigation activities, the monitor wells installed by Dames and Moore, monitor wells 601 through 604, and the monitor wells installed since remedial action began (605 - 625), have periods of water level records that do not overlap. As a result, the potentiometric surface within the bedrock is not fully defined. To define the potentiometric surface, two three-point problems were solved for water levels in wells that were screened in the same interval in the Menefee Formation (Calculation DUR-03-09-90-14-06-00, Appendix A). In addition, one three-point problem was solved for water levels in wells that were screened in the same interval in the Cliff House Formation (Calculation DUR-03-09-90-14-06-00, Appendix A). All three slope directions resulting from these three-point solutions are to the south-southeast coincident with the dip of the Menefee and Cliff House Formations. In summary, the groundwater that occurs within the Cliff House/Menefee aquifer is recharged in the areas of outcrop along the northern edge of Bodo Canyon and to a lesser extent from the overlying alluvium. The groundwater in the Cliff House/Menefee aquifer flows downdip to the south-southeast.

Hydrographs of bedrock monitor well 602 and alluvial monitor well 601 indicate a downward gradient from the alluvium to the Cliff House/Menefee aquifer in the central area of Bodo Canyon for the period of measurement (Figure 3.14). This figure also shows that the general decline in the Cliff House/Menefee aquifer potentiometric surface corresponds to the decline in water level in the

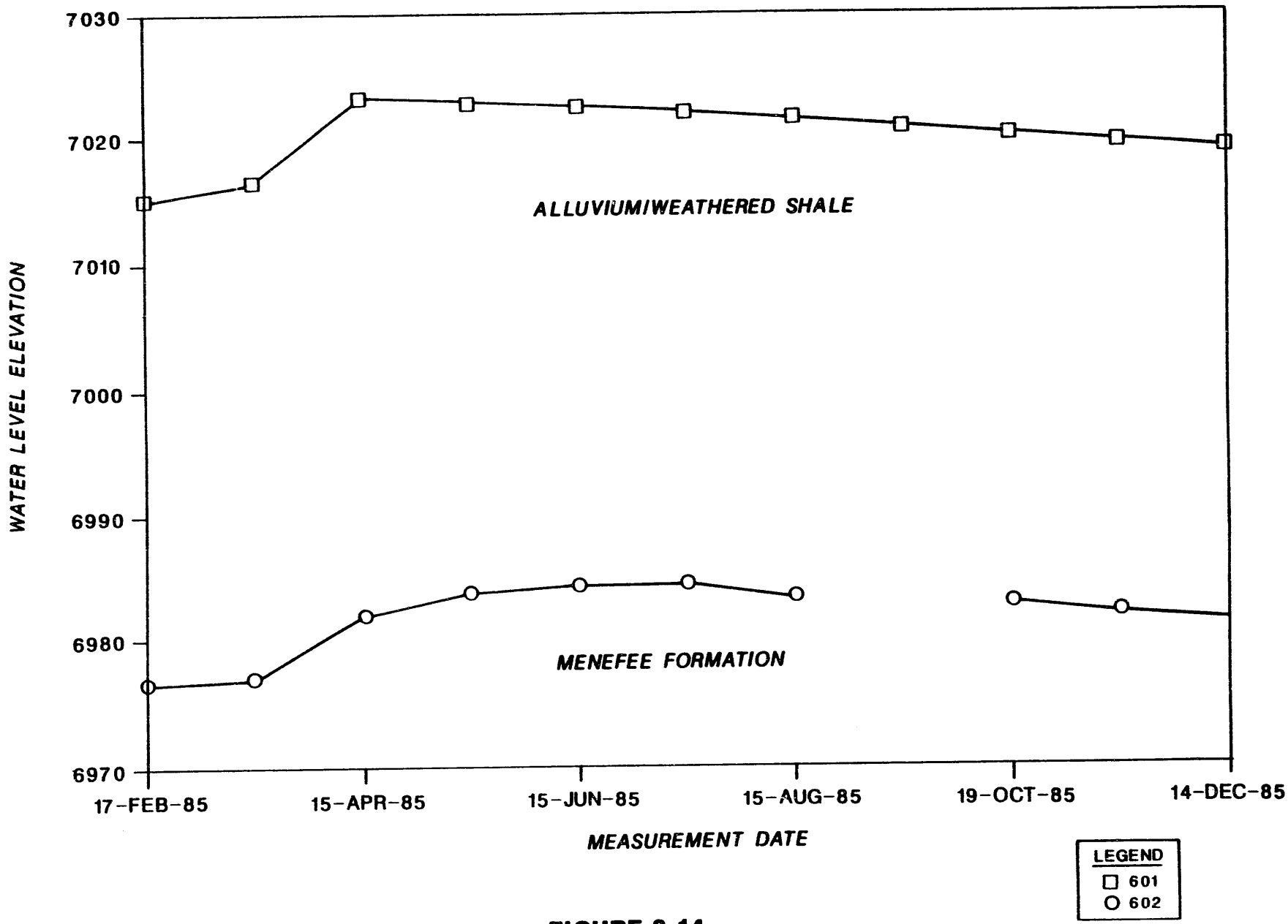

FIGURE 3.14
HYDROGRAPHS OF MONITOR WELLS 601 AND 602
BODO CANYON DISPOSAL SITE, COLORADO

alluvium. Therefore, the Cliff House/Menefee aquifer potentiometric surface under the disposal cell footprint should decline to some extent in response to desaturation of the alluvium. However, water levels will reach a lower, steady state level because underflow from north of Bodo Canyon and recharge from outcrop areas will continue.

3.2.4 Hydraulic characteristics

Field measurements of hydraulic characteristics involved packer testing of selected borehole intervals, slug testing of screened intervals, and pumping aquifer tests of monitor wells. In general, these field methods measure horizontal hydraulic conductivity rather than a bulk or vertical hydraulic conductivity for the tested interval.

Alluvium

In 1989, a 44-hour constant discharge aquifer pumping test was performed by the TAC in a four-inch monitor well completed in the alluvium. Well 608 was pumped at a constant rate of four gallons per minute. Water level measurements in the pumping well and in monitor wells 618 and 620 within the influence of the pumping well were recorded. These aquifer pumping test results are summarized in Table 3.9. Aquifer test data were analyzed using the Theis type curve fitting method and Jacob-Cooper Approximation (Freeze and Cherry, 1979) and the "Well Hydraulics Interpretation Program" (Hydro Geo Chem, 1988) (Calculation DUR-03-09-90-14-03-01, Appendix A). The transmissivity ranges from 150 ft^2/day to 280 ft^2/day. The hydraulic conductivity ranges from 21 ft/day (7.4×10^{-3} cm/s) to 40 ft/day (0.014 cm/s). Hydraulic conductivities were calculated by dividing the transmissivity calculated in each well by the saturated thickness of the alluvium in each well. The storage coefficient ranged from 5×10^{-4} to 0.19.

Hydraulic conductivities determined for the alluvium in aquifer tests conducted before 1989 are also summarized in Table 3.9. These represent saturated hydraulic conductivities determined in both the lab and the field by Dames & Moore (1983) and by the DOE in 1985 (DOE, 1986a) and 1989. Reported hydraulic conductivities often vary over two orders of magnitude, reflecting the natural variability in this parameter and laboratory versus field methods used in analyses.

The alluvium transmissivities in the northeast area of Bodo Basin (monitor wells 606, 608, 613, 618, and 620) are probably much higher than in other areas since this is the area of greatest saturated thickness. The saturated thickness is greatest here for two reasons. First, this area receives groundwater underflow from the adjacent basin to the north of Bodo Basin. Second, all precipitation runoff from the northeastern half of the disposal cell is directed to this area.

Table 3.9 Hydraulic conductivities for hydrostratigraphic units, Bodo Canyon disposal site, Colorado

Hydrostratigraphic unit	Hydraulic conductivity K value (avg. of n)	Source of data[a]
Alluvium (silts and clays >20 feet deep)	0.011 ft/day (n = 8) 3.9×10^{-6} cm/s	JEG, 1985 (lab)[b]
	1.32 ft/day (n = 2) 4.7×10^{-4} cm/s range = 1.19 - 1.46 ft/day	JEG, 1985 (field)[b]
	0.0006 ft/day (n = 2) 2.8×10^{-7} cm/s	Dames & Moore, 1983 (lab)[c]
Weathered sandy shale (upper 15-20 feet of Cliff House)	0.11 ft/day (n = 1) 3.9×10^{-5} cm/s	JEG, 1985 (field)[b]
	1.2 ft/day (n = 11) 4.2×10^{-4} cm/s range = 0.02 - 5.7 ft/day 7.1×10^{-6} cm/s - 2.0×10^{-3} cm	Dames & Moore, 1983 (field)[c]
Sandstone layers and fracture zones (within Cliff House)	0.72 ft/day (n = 11); 2.5×10^{-4} cm/s range = 0.02 - 3.2 ft/day 7.1×10^{-6} cm/s - 1.1×10^{-3} cm/s	Dames & Moore, 1983 (field)[c]
Unweathered sandy shale (Cliff House)	0.006 ft/day (n = 2) 2.1×10^{-6} cm/s	JEG, 1985 (field)[b]
	0.056 ft/day (n = 12) 2.0×10^{-5} cm/s range = 0.0003 - 0.45 ft/day 1.1×10^{-7} cm/s - 1.6×10^{-4} cm/s	Dames & Moore, 1983 (field)[c]
Menefee Shale with coal seams	0.69 ft/day (n = 4) 2.4×10^{-4} cm/s range = 0.36 - 1.39 ft/day 1.3×10^{-4} cm/s - 4.9×10^{-4} cm/s	JEG, 1985 (field)[b]
Menefee Shale with coal seams	0.3 ft/day (n = 2) 1.1×10^{-4} cm/s range = 0.27 - 0.31 ft/day 9.5×10^{-5} cm/s - 1.1×10^{-4} cm/s	DOE, 1989 (field)
Alluvium	32 ft/day (n = 4) range = 21 - 40 ft/day 7.4×10^{-3} - 0.014 cm/s	DOE, 1989 (field)

[a]Field values determined from packer or slug testing of boreholes and wells represent primarily horizontal hydraulic conductivity.
[b]Reported in DOE (1986a).
[c]Reported in Dames and Moore (1983).

The hydraulic conductivities for pre-1989 aquifer tests are within the range of values for silts and clays described by Freeze and Cherry (1979). The data presented here represent horizontal hydraulic conductivity and range from 0.0008 (2.8×10^{-7} cm/s) to 1.32 ft/day (4.7×10^{-4} cm/s). The geometric mean of 1989 and pre-1989 lab and field hydraulic conductivities is 0.13 ft/day. There have been no data collected on the vertical hydraulic conductivity of the alluvium. However, assuming a vertical to horizontal anisotropy ratio of 1:3 (Freeze and Cherry, 1979), the vertical hydraulic conductivity can be estimated at 0.04 ft/day (Calculation DUR-03-09-90-14-03-02, Appendix A).

For the alluvium in the north central area of Bodo Canyon, a hydraulic gradient of the northeastern flow direction of 0.003 ft/ft was calculated based on water table elevation differences between monitor wells 604 and 601 (Calculation DUR-03-09-90-14-06-00, Appendix A).

The average linear groundwater velocity was calculated using Darcy's Law, assuming a porosity of 0.25 and a geometric mean hydraulic conductivity from the aquifer test data. The average linear groundwater velocity of the northeastern component of flow in the north central area is 0.7 ft/year (Calculation DUR-03-10-90-14-07-00, Appendix A).

Cliff House and Menefee Formations

In 1989 a 50-minute constant discharge pumping aquifer test was performed in a four-inch monitor well completed in the Menefee formation. Well 617 was pumped at a constant rate of 0.63 gallons per minute. Water level measurements were recorded in the pumping well and in monitor well 619 within the influence of the pumping well. These aquifer pumping test results are summarized in Table 3.9. Aquifer test data were analyzed using the Theis type curve fitting method and Jacob-Cooper Approximation (Freeze and Cherry, 1979) and the "Well Hydraulics Interpretation Program" (Hydro Geo Chem, 1988) (Calculation DUR-03-09-90-14-03-01, Appendix A). The mean of the two calculated transmissivities is 7.5 ft^2/day. The calculated hydraulic conductivity is 0.3 ft/day (1.1×10^{-4} cm/s). Hydraulic conductivities were calculated by dividing the transmissivity calculated in the well by the thickness of the coal beds in the well, since these units probably transmit much more water than the surrounding siltstone and shale. The calculated storage coefficient is 4×10^{-4}.

A summary of pre-1989 aquifer test results for the Cliff House and Menefee Formations is presented in Table 3.9. The hydraulic conductivities range from 3.0×10^{-4} ft/day (9.7×10^{-8} cm/s) to 5.7 ft/day (2.0×10^{-3} cm/s). The highest hydraulic conductivities occur in shallow, weathered bedrock, fracture zones, and along coal seams. The lower hydraulic conductivities occur in indurated shale and sandstone units. The geometric mean of all field hydraulic conductivities is 0.07 ft/day. There are no data available

concerning the vertical hydraulic conductivity of the various strata in the deeper system.

Three hydraulic gradients were calculated from the three three-point solutions used to define the southeastern direction of groundwater flow. The average horizontal hydraulic gradient is 0.19 ft/ft (Calculation DUR-03-09-90-14-06-00, Appendix A).

The average linear groundwater velocity was calculated using Darcy's law, assuming a porosity of 0.15 and the geometric mean hydraulic conductivity (0.07 ft/day). The average groundwater linear velocity to the southeast is 32 ft/year in the Cliff House and Menefee Formations (Calculation DUR-03-10-90-14-07-00, Appendix A).

3.2.5 Background groundwater quality

Background water quality was characterized by analyzing constituents listed in Table 8.1 of the Technical Approach Document (TAD) (DOE, 1989). Background water quality can be characterized by describing an average concentration and a statistical maximum. The procedures for calculating average and statistical maximum concentrations are discussed in "Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities-Interim Final Guidance" (EPA, 1989) and are described in the TAD. Average concentrations of hazardous constituents are represented statistically by a mean or median depending on the proportion of nondetects and whether the distribution is normal or nonparametric. The statistical maximum may be represented as the 99 percent confidence maximum for normal or lognormal distributions or a nonparametric confidence interval if the distribution is either normal or log normal. In some cases, it is not appropriate to use statistics and the maximum observed concentration is chosen as a "statistical maximum." In other cases, the statistical maximum may be the detection limit.

Alluvium

Monitor well 623 provides background water quality data for the alluvium in the disposal site area. Monitor well 623 is located in a small, alluvium-filled basin north of Bodo Basin (Figure 3.6). These two basins are separated by a bedrock ridge. Monitor wells located in the northeast area of Bodo Canyon cannot be considered background wells since the alluvial groundwater quality in this area has been affected by construction activities. This subject will be discussed below.

Background groundwater quality in the alluvium at the Bodo Canyon disposal site is presented in Table 3.10. This table lists the constituent, number of samples, minimum and maximum concentration observed, mean and median concentration, standard deviation, percent of nondetects, statistical range (99 percent one-sided

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	7	441.0000	2892.0000	495.0000	622.5449	1.9796	NA	0.0	276.6027	1401.1509	LOGNORMAL	7,8
ALUMINUM	MG/L	3	** 0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	1	0.5000	0.5000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY	MG/L	7	** 0.0030	0.0100	** 0.0030	NA	NA	NA	85.7	** 0.0030	0.0100	NONPARAMETRIC	2
ARSENIC	MG/L	7	0.0020	0.0150	0.0050	NA	NA	NA	85.7	0.0020	0.0150	NONPARAMETRIC	2
BARIUM	MG/L	7	0.0200	0.1400	0.0500	NA	NA	NA	42.9	0.0200	0.1400	NONPARAMETRIC	2
BERYLLIUM	MG/L	7	** 0.0050	0.0050	** 0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2
CADMIUM	MG/L	7	0.0002	0.0005	0.0005	NA	NA	NA	85.7	0.0002	0.0005	NONPARAMETRIC	2
CALCIUM	MG/L	7	226.0000	284.0000	252.0000	253.1429	18.0410	0.0713	0.0	231.7112	274.5745	NORMAL	
CHLORIDE	MG/L	7	14.0000	40.5000	39.0000	35.0714	9.4799	0.2703	0.0	23.8098	46.3330	NORMAL	

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM	MG/L	7	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT	MG/L	6	0.0100	0.0250	+ 0.0250	NA	NA	NA	83.3	0.0100	0.0250	NONPARAMETRIC	2,6
COPPER	MG/L	7	** 0.0100	0.0100	0.0100	NA	NA	NA	85.7	** 0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE	MG/L	7	0.2000	0.5000	0.4000	0.4000	0.1155	0.2887	0.0	0.2628	0.5372	NORMAL	
GROSS ALPHA	PCI/L	5	** 1.0000	23.8000	** 1.0000	NA	NA	NA	40.0	** 1.0000	23.8000	NONPARAMETRIC	2,5
GROSS BETA	PCI/L	7	8.0000	33.8000	10.1000	14.3143	9.3983	0.6566	0.0	3.1496	25.4789	NORMAL	
IRON	MG/L	7	** 0.0300	1.2200	0.3300	NA	NA	NA	28.6	** 0.0300	1.2200	NONPARAMETRIC	2
LEAD	MG/L	7	** 0.0050	0.0050	0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM	MG/L	7	195.0000	227.0000	218.0000	214.7143	12.4058	0.0578	0.0	199.9769	229.4517	NORMAL	
MANGANESE	MG/L	7	0.3900	0.9800	0.6500	0.6371	0.1915	0.3005	0.0	0.4097	0.8646	NORMAL	
MERCURY	MG/L	7	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	** 0.0002	** 0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	7	** 0.0060	0.2000	0.0060	NA	NA	NA	42.9	** 0.0060	0.2000	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	5	-0.6900	22.4300	-0.5300	NA	NA	NA	0.0	-0.6900	22.4300	NONPARAMETRIC	9,5
NICKEL	MG/L	7	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	** 0.0400	** 0.0400	NONPARAMETRIC	2
NITRATE	MG/L	7	0.4000	10.2000	0.5000	NA	NA	NA	42.9	0.4000	10.2000	NONPARAMETRIC	2
NITRITE AND NITRATE	MG/L	1	0.4700	0.4700	0.4700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
PH	SU	7	6.9500	7.3300	7.0600	NA	NA	NA	0.0	NA	NA	UNKNOWN	

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
POTASSIUM	MG/L	7	2.9000	11.0000	4.1000	5.1000	2.8676	0.5623	0.0	1.6934	8.5066	NORMAL	
RADIUM-226	PCI/L	7	** 0.1000	34.9000	0.2000	0.3292	8.8195	NA	14.3	** 0.1000	4.3708	LOGNORMAL	7,8
RADIUM-226 + RADIUM-228	PCI/L	7	0.3000	35.4000	1.4500	1.9445	4.3618	NA	0.0	0.3380	11.1862	LOGNORMAL	7,8
RADIUM-228	PCI/L	7	** 1.0000	3.3000	1.2000	NA	NA	NA	14.3	** 1.0000	3.3000	NONPARAMETRIC	9
REDOX POTENTIAL	mVOLTS	1	185.6000	185.6000	185.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	7	** 0.0020	0.0250	0.0025	NA	NA	NA	100.0	** 0.0020	0.0250	NONPARAMETRIC	2
SILVER	MG/L	7	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
SODIUM	MG/L	7	114.0000	176.0000	168.0000	160.7143	21.1638	0.1317	0.0	135.5730	185.8556	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	7	100.0000	2760.0000	1700.0000	1459.0000	902.3287	0.6185	0.0	387.0856	2530.9144	NORMAL	

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
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PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
STRONTIUM	MG/L	3	2.1500	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE	MG/L	7	1299.0000	1360.0000	1320.0000	1329.8571	26.0156	0.0196	0.0	1298.9522	1360.7621	NORMAL	
SULFIDE	MG/L	4	** 0.1000	8.0000	+ 0.4000	NA	NA	NA	25.0	** 0.1000	8.0000	NONPARAMETRIC	2,4
TEMPERATURE	C - DEGREE	7	6.0000	9.5000	9.0000	8.2857	1.5774	0.1904	0.0	6.4119	10.1595	NORMAL	
THALLIUM	MG/L	6	** 0.0010	0.0500	+ 0.0100	NA	NA	NA	100.0	** 0.0010	0.0500	NONPARAMETRIC	2,6
TIN	MG/L	6	** 0.0050	0.0250	+ 0.0085	NA	NA	NA	50.0	** 0.0050	0.0250	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS	MG/L	7	2240.0000	2490.0000	2340.0000	2369.7143	81.5715	0.0344	0.0	2272.8121	2466.6165	NORMAL	
TOTAL ORGANIC CARBON	MG/L	2	10.0000	33.0000	+ 21.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM	MG/L	7	0.0010	0.0020	0.0015	NA	NA	NA	42.9	0.0010	0.0020	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.10 - BACKGROUND MONITOR WELL 623, GROUNDWATER QUALITY STATISTICS
BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
10/27/89 TO 08/07/91
REPORT DATE: 12/16/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM	MG/L	7	** 0.0100	0.0200	** 0.0100	NA	NA	NA	57.1	** 0.0100	0.0200	NONPARAMETRIC	2
ZINC	MG/L	7	** 0.0050	0.0400	** 0.0050	NA	NA	NA	85.7	** 0.0050	0.0400	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

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confidence interval, statistical minimum, and statistical maximum), and the distribution type.

Background concentrations in the alluvial groundwater were compared with concentrations observed in the alluvial groundwater downgradient of the disposal cell to determine if groundwater in this unit has been affected by the disposal cell seepage or retention pond discharges. Concentrations or activities of molybdenum, net gross alpha, and radium-226 and -228 in filtered samples have exceeded MCLs at least once in background alluvial monitor well 623 (Table 3.10).

Cliff House and Menefee Formations

Since no mining or industrial activities have taken place in the Bodo Canyon area, all bedrock monitor wells hydraulically upgradient, cross gradient, and downgradient of the disposal cell were used to establish background water quality during tailings relocation and disposal. Monitor wells 605, 607, 609, 611, 612, 616, 617, 621, 624, and 625 provide background water quality data for the bedrock Cliff House Formation and Menefee Formation in the disposal site area (Figure 3.6). A statistical treatment of background water quality from all monitoring wells in the Cliff House and Menefee Formations prior to disposal cell completion that includes the minimum, mean, median, maximum, percentage of nondetects, the 99 percent confidence interval and other important statistical parameters is provided in Table 3.11.

Hazardous constituents with MCLs with concentrations that exceeded the laboratory method detection limits in the Cliff House and Menefee monitor wells include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, and uranium. Elements or compounds that are listed as hazardous constituents in Appendix I of 40 CFR 192 and Appendix IX of 40 CFR 264 with concentrations that exceeded the laboratory method detection limits include antimony, beryllium, cobalt, copper, nickel, sulfide, thallium, tin, vanadium, and zinc.

Maximum observed concentrations of five hazardous constituents equalled or exceeded MCLs in the Cliff House and Menefee groundwater system (Table 3.11). These constituents include cadmium, chromium, molybdenum, net gross alpha, radium-226 and -228, selenium, and uranium. The lower end of the 98 percent confidence interval for these constituents by monitor well was compared with the MCL. According to "Statistical Analyses of Ground-Water Monitoring Data at RCRA Facilities - Interim Final Guidance" (EPA, 1989), if the lower end of the confidence interval exceeds the MCLs, there is statistical evidence of an exceedance of the MCLs. The lower end of the 98 percent confidence interval concentrations of these constituents do not exceed MCLs. Background groundwater quality in the Cliff House and Menefee Formations has pH values that range from 6.6 to 8.3. The average TDS is 2913 mg/l.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 10/30/90
REPORT DATE: 12/17/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	47	10.0000	1449.0000	716.0000	700.7021	337.7677	0.4820	0.0	581.9651	819.4392	NORMAL	
ALUMINUM	MG/L	5	** 0.1000	7.5000	** 0.1000	NA	NA	NA	60.0	** 0.1000	7.5000	NONPARAMETRIC	2,5
AMMONIUM	MG/L	16	0.8000	6.2000	+ 1.7500	2.2275	1.5659	0.7030	0.0	1.2089	3.2461	NORMAL	
ANTIMONY	MG/L	29	** 0.0030	0.0270	** 0.0030	NA	NA	NA	72.4	** 0.0030	0.0100	NONPARAMETRIC	2
ARSENIC	MG/L	45	0.0050	0.0240	0.0050	NA	NA	NA	82.2	0.0050	0.0050	NONPARAMETRIC	2
BARIUM	MG/L	41	0.0100	0.1000	0.0500	NA	NA	NA	75.6	0.0500	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	32	** 0.0050	0.0230	+ 0.0050	NA	NA	NA	93.8	0.0050	0.0050	NONPARAMETRIC	2
CADMIUM	MG/L	45	** 0.0010	0.0190	** 0.0010	NA	NA	NA	73.3	** 0.0010	0.0010	NONPARAMETRIC	2
CALCIUM	MG/L	45	2.2500	505.0000	149.0000	180.9273	165.6537	0.9156	0.0	121.3155	240.5391	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	3	8.0000	52.0000	12.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
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PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE	MG/L	44	8.0000	428.0000	+ 37.0000	34.6289	2.1060	NA	0.0	26.4015	45.4201	LOGNORMAL	7,8
CHROMIUM	MG/L	41	** 0.0100	0.1200	** 0.0100	NA	NA	NA	82.9	** 0.0100	** 0.0100	NONPARAMETRIC	2
COBALT	MG/L	32	** 0.0300	0.0400	** 0.0300	NA	NA	NA	96.9	** 0.0300	** 0.0300	NONPARAMETRIC	2
COPPER	MG/L	41	** 0.0100	0.0300	0.0100	NA	NA	NA	92.7	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	23	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
FLUORIDE	MG/L	40	0.1000	3.7500	+ 0.3600	0.5695	2.6257	NA	0.0	0.3933	0.8246	LOGNORMAL	7,8
GROSS ALPHA	PCI/L	35	** 0.2000	38.0000	4.0000	NA	NA	NA	28.6	0.5000	14.0000	NONPARAMETRIC	2
GROSS BETA	PCI/L	40	1.3000	62.0000	+ 17.6500	20.5725	13.0657	0.6351	0.0	15.5628	25.5822	NORMAL	
IRON	MG/L	45	** 0.0300	231.0000	0.3000	0.5966	11.9449	NA	2.2	0.2444	1.4566	LOGNORMAL	7,8
LEAD	MG/L	41	** 0.0100	0.0200	** 0.0100	NA	NA	NA	80.5	** 0.0100	** 0.0100	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 10/30/90
REPORT DATE: 12/17/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM	MG/L	45	0.2400	458.0000	125.0000	36.6936	10.3050	NA	0.0	15.8502	84.9462	LOGNORMAL	7,8
MANGANESE	MG/L	45	** 0.0100	5.0000	0.0600	0.0898	6.6858	NA	8.9	0.0453	0.1779	LOGNORMAL	7,8
MERCURY	MG/L	40	** 0.0002	0.0004	** 0.0002	NA	NA	NA	90.0	** 0.0002	** 0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	45	** 0.0100	0.2200	0.0100	NA	NA	NA	46.7	** 0.0100	0.0500	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	32	-50.1200	34.6400	+ 2.7150	NA	NA	NA	0.0	-0.3100	13.9200	NONPARAMETRIC	9
NICKEL	MG/L	32	** 0.0400	0.0700	** 0.0400	NA	NA	NA	90.6	** 0.0400	** 0.0400	NONPARAMETRIC	2
NITRATE	MG/L	39	** 0.9000	10.0000	0.9000	NA	NA	NA	48.7	** 0.9000	1.8000	NONPARAMETRIC	2
NITRITE AND NITRATE	MG/L	13	0.1600	0.6000	0.5000	NA	NA	NA	53.8	0.3600	0.5900	NONPARAMETRIC	2
PH	SU	47	4.9100	12.9800	6.9200	NA	NA	NA	0.0	NA	NA	UNKNOWN	

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 10/30/90
REPORT DATE: 12/17/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
POTASSIUM	MG/L	45	5.0000	39.8000	7.3000	11.0424	8.7577	0.7931	0.0	7.8909	14.1940	NORMAL	
RADIUM-226	PCI/L	44	** 0.1000	2.0000	+ 0.1000	NA	NA	NA	18.2	0.1000	0.2000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228	PCI/L	44	0.2000	5.0000	+ 0.6250	1.0614	0.9828	0.9260	0.0	0.7034	1.4193	NORMAL	
RADIUM-228	PCI/L	44	** 0.9000	4.7000	** 0.9000	NA	NA	NA	43.2	** 0.9000	** 0.9000	NONPARAMETRIC	2
REDOX POTENTIAL	mVOLTS	7	57.9000	768.3000	174.6000	258.9000	243.1119	0.9390	0.0	-29.9029	547.7029	NORMAL	
SELENIUM	MG/L	45	0.0010	0.0420	0.0060	NA	NA	NA	60.0	0.0025	0.0150	NONPARAMETRIC	2
SILVER	MG/L	45	** 0.0100	0.0300	** 0.0100	NA	NA	NA	95.6	** 0.0100	** 0.0100	NONPARAMETRIC	2
SODIUM	MG/L	45	157.0000	861.0000	313.0000	389.7778	190.2960	0.4882	0.0	321.2982	458.2573	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	47	335.0000	5410.0000	1925.0000	2251.1489	1084.7814	0.4819	0.0	1869.8107	2632.4872	NORMAL	
STRONTIUM	MG/L	5	0.6000	7.7000	7.2000	5.7000	2.9983	0.5260	0.0	0.6757	10.7243	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 10/30/90
REPORT DATE: 12/17/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFATE	MG/L	44	127.0000	3820.0000	+ 882.0000	1265.8409	1108.8551	0.8760	0.0	861.9674	1669.7144	NORMAL	
SULFIDE	MG/L	26	** 0.1000	42.2000	+ 1.2500	NA	NA	NA	34.6	** 0.1000	6.4000	NONPARAMETRIC	2
TEMPERATURE	C - DEGREE	47	10.0000	20.0000	11.5000	11.5915	1.5854	0.1368	0.0	11.0342	12.1488	NORMAL	
THALLIUM	MG/L	32	** 0.0100	0.0150	** 0.0100	NA	NA	NA	96.9	** 0.0100	** 0.0100	NONPARAMETRIC	2
THORIUM-230	PCI/L	4	** 0.1000	0.3000	+ 0.1250	NA	NA	NA	50.0	** 0.1000	0.3000	NONPARAMETRIC	2,4
TIN	MG/L	32	** 0.0050	0.0390	** 0.0050	NA	NA	NA	71.9	** 0.0050	0.0130	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS	MG/L	43	670.0000	7440.0000	2270.0000	2705.4884	1496.7427	0.5532	0.0	2153.5771	3257.3996	NORMAL	
URANIUM	MG/L	42	0.0003	0.0770	+ 0.0015	NA	NA	NA	31.0	0.0011	0.0030	NONPARAMETRIC	2
VANADIUM	MG/L	32	** 0.0100	0.0600	+ 0.0100	NA	NA	NA	34.4	** 0.0100	0.0200	NONPARAMETRIC	2
ZINC	MG/L	41	** 0.0050	0.1350	0.0070	NA	NA	NA	43.9	** 0.0050	0.0130	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

TABLE 3.11 - CLIFF HOUSE/MENEFEE AQUIFER MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER 1987 - 1990, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 10/30/90
REPORT DATE: 12/17/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE

* The statistical maximum is the 99 percent one sided confidence interval, α = 0.01

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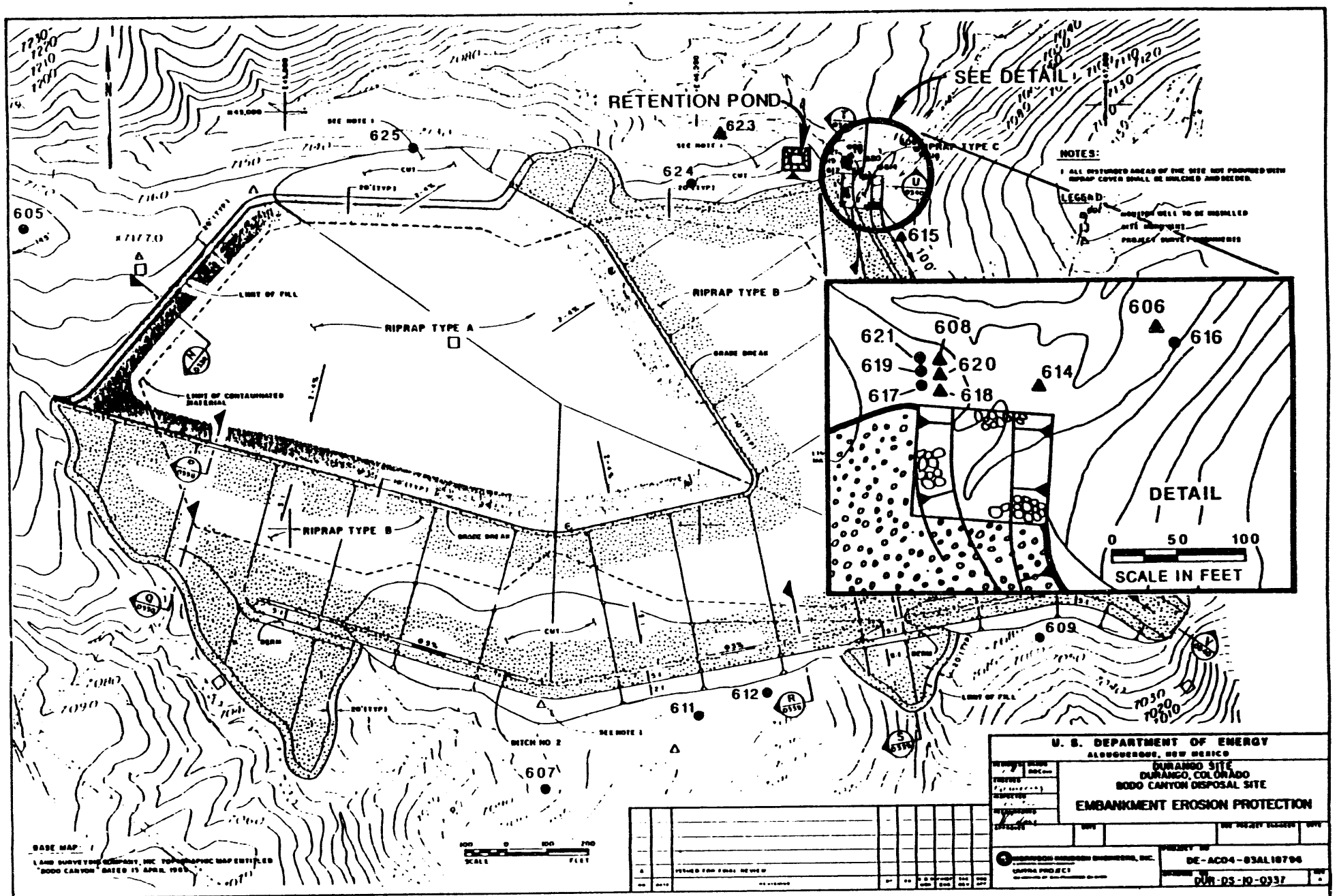
3.2.6 Downgradient alluvial groundwater quality

A retention pond (DS-1) (Figure 3.15) served as a catchment for contaminated surface runoff downslope from the Bodo Canyon disposal cell during the three-year construction period. Surface water that collected in the pond was periodically treated with barium chloride and discharged downslope in an arroyo trending northeastward from the disposal cell. The treatment process was effective in removing radium, yet it had little effect on the other hazardous constituents of concern (Edge, 1989). In October 1988, a seep appeared on the east face of the disposal cell. As a remediation measure, a pilot dewatering program was initiated in November 1988 and a subsurface toe drain was constructed to collect the tailings pore water from the seep and convey it to the retention pond.

To assess groundwater quality changes, alluvial groundwater quality data have been collected by the DOE on a quarterly basis since 1987, and on a monthly basis where possible from December 1989 to October 1990 from four downgradient monitor wells (606, 608, 614, and 615) and one upgradient monitor well (623) (Figure 3.6). Monitor well 615 was abandoned in 1989 due to construction activities. Monitor well 618 was sampled three times and monitor well 620 was sampled once since installation. Groundwater quality was characterized by analyzing constituents listed in Table 8.1 of the Technical Approach Document (TAD) (DOE, 1989).

A statistical analysis of downgradient alluvial groundwater quality from September 1987 to October 1990 is presented in Table 3.12. Concentrations or activities of hazardous constituents with MCLs that exceeded the laboratory method detection limits in downgradient alluvial monitor wells at the disposal site are also listed in this table. These include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. Concentrations of elements included individually or as compounds that are listed as hazardous constituents in Appendix I of 40 CFR 192 and Appendix IX of 40 CFR 264 that exceeded the laboratory method detection limits in downgradient alluvial groundwater include antimony, copper, cyanide, fluoride, nickel, strontium, sulfide, vanadium, and zinc.

Maximum observed concentrations or activities of seven hazardous constituents equalled or exceeded proposed EPA MCLs in the alluvial groundwater in at least one monitor well downgradient of the disposal cell (Table 3.12). These constituents include chromium, lead, molybdenum, net gross alpha, radium-226 and -228, selenium, and uranium. All of these constituents also exceeded laboratory method detection limits in the tailings pore water. However, molybdenum, net gross alpha, and radium-226 and -228 MCL exceedances were also observed in background monitor well 623 samples.



LEGEND

● BEDROCK MONITOR WELL

▲ ALLUVIAL MONITOR WELL

FIGURE 3.15
WELL LOCATIONS, BODO CANYON DISPOSAL SITE

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS										
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY					MG/L CACO3							
0606	9	322.0000	581.0000	377.0000	411.0000	81.4647	0.1982	0.0	332.3594	489.6406	NORMAL	
0608	14	310.0000	461.0000	+ 388.0000	388.4286	37.0358	0.0953	0.0	362.1983	414.6589	NORMAL	
0614	7	274.0000	401.0000	398.0000	369.0000	50.1664	0.1360	0.0	309.4052	428.5948	NORMAL	
0615	3	420.0000	959.0000	715.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	418.0000	432.0000	423.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	426.0000	426.0000	426.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ALUMINUM					MG/L							
0606	2	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	4	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	** 0.0500	0.0500	NONPARAMETRIC	2,4
0614	3	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	2	** 0.0500	0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM					MG/L							
0606	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0614	2	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ANTIMONY					MG/L							
0606	5	** 0.0030	** 0.0030	** 0.0030	NA	NA	NA	100.0	** 0.0030	** 0.0030	NONPARAMETRIC	2,5
0608	8	** 0.0030	** 0.0030	** 0.0030	NA	NA	NA	100.0	** 0.0030	** 0.0030	NONPARAMETRIC	2
0614	7	** 0.0030	0.0100	** 0.0030	NA	NA	NA	100.0	** 0.0030	0.0100	NONPARAMETRIC	2
0615	3	** 0.0020	0.0050	0.0020	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	** 0.0030	0.0100	** 0.0030	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0200	** 0.0200	** 0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC					MG/L							
0606	11	** 0.0070	0.0200	** 0.0070	NA	NA	NA	72.7	** 0.0070	0.0070	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL				
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ARSENIC					MG/L							
0608	15	0.0040	0.0100	0.0050	NA	NA	NA	86.7	0.0050	0.0050	NONPARAMETRIC	2
0614	7	** 0.0100	0.0150	** 0.0100	NA	NA	NA	100.0	** 0.0100	0.0150	NONPARAMETRIC	2
0615	3	0.0010	0.0050	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0150	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BARIUM					MG/L							
0606	9	0.0200	0.0500	0.0500	NA	NA	NA	66.7	0.0200	0.0500	NONPARAMETRIC	2
0608	13	0.0400	0.0600	0.0500	NA	NA	NA	53.8	0.0400	0.0500	NONPARAMETRIC	2
0614	6	0.0200	0.0500	+ 0.0500	NA	NA	NA	66.7	0.0200	0.0500	NONPARAMETRIC	2,6
0615	3	0.0300	0.0500	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	2	0.0200	0.0500	+ 0.0350	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0620	1	0.0200	0.0200	0.0200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
BERYLLIUM					MG/L							
0606	6	** 0.0050	0.0050	** 0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2,6
0608	10	** 0.0050	0.0050	** 0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2
0614	7	** 0.0050	0.0050	0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2
0615	3	** 0.0050	0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0050	0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CADMIUM					MG/L							
0606	11	** 0.0010	0.0080	** 0.0010	NA	NA	NA	81.8	** 0.0010	0.0030	NONPARAMETRIC	2
0608	15	** 0.0010	0.0070	** 0.0010	NA	NA	NA	80.0	** 0.0010	0.0025	NONPARAMETRIC	2
0614	7	** 0.0010	** 0.0010	** 0.0010	NA	NA	NA	100.0	** 0.0010	** 0.0010	NONPARAMETRIC	2
0615	3	0.0003	0.0010	0.0005	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	** 0.0010	** 0.0010	** 0.0010	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0010	** 0.0010	** 0.0010	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CALCIUM					MG/L							
0606	11	0.0400	432.0000	298.0000	275.8218	141.1253	0.5117	0.0	158.2112	393.4325	NORMAL	

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 95% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CALCIUM				MG/L								
0608	15	122.0000	251.0000	217.0000	216.2000	32.8573	0.1520	0.0	193.9387	238.4613	NORMAL	
0614	7	205.0000	294.0000	281.0000	264.8571	37.4407	0.1414	0.0	220.3797	309.3346	NORMAL	
0615	3	85.0000	178.0000	132.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	260.0000	280.0000	278.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	280.0000	280.0000	280.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHEMICAL OXYGEN DEMAND				MG/L								
0606	1	12.0000	12.0000	12.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	1	8.0000	8.0000	8.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE				MG/L								
0606	11	** 1.0000	29.8000	10.9000	12.0182	7.5535	0.6285	9.1	5.7233	18.3131	NORMAL	
0608	15	14.0000	44.0000	31.0000	31.2800	7.1047	0.2271	0.0	26.4664	36.0936	NORMAL	
0614	7	29.0000	43.0000	38.7000	37.1000	5.2887	0.1426	0.0	30.8174	43.3826	NORMAL	
0615	3	31.5000	43.0000	39.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	40.0000	45.0000	40.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	44.8000	44.8000	44.8000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHROMIUM				MG/L								
0606	9	** 0.0100	0.1300	** 0.0100	NA	NA	NA	66.7	** 0.0100	0.1300	NONPARAMETRIC	2
0608	13	** 0.0100	0.0900	** 0.0100	NA	NA	NA	84.6	** 0.0100	0.0800	NONPARAMETRIC	2
0614	7	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
0615	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COBALT				MG/L								
0606	5	0.0200	0.0250	0.0250	NA	NA	NA	80.0	0.0200	0.0250	NONPARAMETRIC	2,5
0608	8	0.0100	0.0250	+ 0.0250	NA	NA	NA	87.5	0.0100	0.0250	NONPARAMETRIC	2
0614	6	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	** 0.0300	** 0.0300	NONPARAMETRIC	2,6

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS						STATISTICAL RANGE 98% CONFIDENCE INTERVAL				
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COBALT					MG/L							
0615	3	0.0200	0.0250	0.0250	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COPPER					MG/L							
0606	9	** 0.0100	0.0200	0.0100	NA	NA	NA	88.9	** 0.0100	0.0200	NONPARAMETRIC	2
0608	13	** 0.0100	0.0200	0.0100	NA	NA	NA	92.3	** 0.0100	0.0100	NONPARAMETRIC	2
0614	7	** 0.0100	0.0100	0.0100	NA	NA	NA	100.0	** 0.0100	0.0100	NONPARAMETRIC	2
0615	3	** 0.0200	** 0.0200	** 0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CYANIDE					MG/L							
0606	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	5	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2,5
0614	4	** 0.0100	0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	0.0100	NONPARAMETRIC	2,4
0615	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0300	0.0100	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE					MG/L							
0606	9	** 0.1000	0.5000	0.4000	0.3944	0.1380	0.3499	11.1	0.2612	0.5277	NORMAL	
0608	13	0.3000	0.4000	0.3700	0.3508	0.0496	0.1413	0.0	0.3139	0.3876	NORMAL	
0614	7	0.2000	0.3000	0.2000	0.2429	0.0535	0.2201	0.0	0.1794	0.3064	NORMAL	
0615	3	0.4000	0.6000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.3000	0.4000	0.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.4000	0.4000	0.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS ALPHA					PCI/L							
0606	9	** 0.2000	69.0000	3.2000	NA	NA	NA	33.3	** 0.2000	69.0000	NONPARAMETRIC	2
0608	12	** 0.2000	19.0000	+ 3.2000	NA	NA	NA	16.7	0.5000	10.0000	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
GROSS ALPHA					PCI/L							
0614	6	** 1.0000	38.2000	+ 8.9000	NA	NA	NA	16.7	** 1.0000	38.2000	NONPARAMETRIC	2,6
0615	3	** 1.0000	46.0000	29.3000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	2	1.9000	10.9000	+ 6.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	** 1.0000	** 1.0000	** 1.0000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
GROSS BETA					PCI/L							
0606	9	** 0.5000	32.0000	15.0000	NA	NA	NA	0.0	** 0.5000	32.0000	NONPARAMETRIC	9
0608	13	** 0.5000	20.5000	7.4000	NA	NA	NA	7.7	** 0.5000	16.0000	NONPARAMETRIC	9
0614	7	** 0.5000	11.0000	8.2000	NA	NA	NA	14.3	** 0.5000	11.0000	NONPARAMETRIC	9
0615	3	24.2000	40.4000	27.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	** 0.5000	14.3000	9.5000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	4.0000	4.0000	4.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
IRON					MG/L							
0606	11	** 0.0300	2.4700	0.0900	NA	NA	NA	36.4	** 0.0300	1.6800	NONPARAMETRIC	2
0608	15	** 0.0300	0.0700	0.0500	NA	NA	NA	46.7	** 0.0300	0.0700	NONPARAMETRIC	2
0614	7	** 0.0300	0.2000	0.0600	NA	NA	NA	28.6	** 0.0300	0.2000	NONPARAMETRIC	2
0615	3	** 0.0300	0.0400	** 0.0300	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	** 0.0300	0.0800	0.0300	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
LEAD					MG/L							
0606	9	** 0.0100	0.0150	** 0.0100	NA	NA	NA	100.0	** 0.0100	0.0150	NONPARAMETRIC	2
0608	13	** 0.0050	0.0600	0.0050	NA	NA	NA	84.6	** 0.0050	0.0100	NONPARAMETRIC	2
0614	7	** 0.0050	0.0050	0.0050	NA	NA	NA	100.0	** 0.0050	0.0050	NONPARAMETRIC	2
0615	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MAGNESIUM					MG/L							
0606	11	0.0400	225.0000	176.0000	149.8218	67.9115	0.4533	0.0	93.2260	206.4177	NORMAL	

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* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS				STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM				MG/L								
0608	15	109.0000	158.0000	140.0000	138.2000	12.8519	0.0930	0.0	129.4927	146.9073	NORMAL	
0614	7	97.1000	144.0000	127.0000	123.1571	16.8999	0.1372	0.0	103.0811	143.2332	NORMAL	
0615	3	53.0000	102.0000	81.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	139.0000	152.0000	145.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	173.0000	173.0000	173.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MANGANESE				MG/L								
0606	11	** 0.0100	2.9800	0.9700	1.0468	0.9467	0.9044	9.1	0.2579	1.8358	NORMAL	
0608	15	** 0.0100	0.0600	0.0100	NA	NA	NA	46.7	** 0.0100	0.0400	NONPARAMETRIC	2
0614	7	** 0.0100	0.1500	0.0200	NA	NA	NA	28.6	** 0.0100	0.1500	NONPARAMETRIC	2
0615	3	0.1100	0.2900	0.1700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MERCURY				MG/L								
0606	11	** 0.0002	0.0004	** 0.0002	NA	NA	NA	90.9	** 0.0002	** 0.0002	NONPARAMETRIC	2
0608	15	** 0.0002	0.0014	** 0.0002	NA	NA	NA	86.7	** 0.0002	** 0.0002	NONPARAMETRIC	2
0614	6	** 0.0002	0.0002	** 0.0002	NA	NA	NA	83.3	** 0.0002	0.0002	NONPARAMETRIC	2,6
0615	3	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0002	** 0.0002	** 0.0002	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MOLYBDENUM				MG/L								
0606	11	0.0040	0.2000	0.0050	NA	NA	NA	54.5	0.0050	0.0800	NONPARAMETRIC	2
0608	15	0.0020	0.1000	0.0050	NA	NA	NA	46.7	0.0050	0.0600	NONPARAMETRIC	2
0614	7	** 0.0100	0.0300	** 0.0100	NA	NA	NA	85.7	** 0.0100	0.0300	NONPARAMETRIC	2
0615	3	0.0500	0.1020	0.0900	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0300	** 0.0100	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NET GROSS ALPHA ***				PCI/L								
0606	9	-5.3900	63.7200	3.1000	NA	NA	NA	0.0	-5.3900	63.7200	NONPARAMETRIC	9

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS						STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
WET GROSS ALPHA ***				PCI/L								
0608	12	-2.9300	16.1900	+ 0.4550	NA	NA	NA	0.0	-2.7400	8.8600	NONPARAMETRIC	9
0614	6	-3.1400	37.8600	+ 6.0550	NA	NA	NA	0.0	-3.1400	37.8600	NONPARAMETRIC	9,6
0615	3	-59.1800	30.9100	5.9800	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	2	-0.1600	10.2100	+ 5.0250	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	-1.5600	-1.5600	-1.5600	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NICKEL				MG/L								
0606	6	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	** 0.0400	** 0.0400	NONPARAMETRIC	2,6
0608	9	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	** 0.0400	** 0.0400	NONPARAMETRIC	2
0614	7	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	** 0.0400	** 0.0400	NONPARAMETRIC	2
0615	3	0.0200	0.0200	0.0200	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0400	** 0.0400	** 0.0400	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRATE				MG/L								
0606	9	0.1000	17.3000	0.5000	NA	NA	NA	44.4	0.1000	17.3000	NONPARAMETRIC	2
0608	13	1.2000	15.9000	3.1000	4.7000	3.8293	0.8147	0.0	1.8526	7.5474	NORMAL	
0614	7	** 1.0000	15.1000	6.0000	6.2286	5.1490	0.8267	14.3	** 1.0000	12.3453	NORMAL	
0615	3	** 1.0000	11.2000	5.2000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	2.0000	5.8000	5.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	3.1000	3.1000	3.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NITRITE AND NITRATE				MG/L								
0614	2	** 1.0000	1.6800	+ 1.0900	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0618	1	1.3200	1.3200	1.3200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.7500	0.7500	0.7500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
PH				SU								
0606	12	6.7700	7.3100	+ 7.0382	NA	NA	NA	0.0	NA	NA	UNKNOWN	

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS						STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
PH				SU								
0608	15	6.8000	9.8000	7.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	
0614	7	5.4500	7.3800	7.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	
0615	4	7.3000	7.9000	+ 7.7599	NA	NA	NA	0.0	NA	NA	UNKNOWN	
0618	3	6.8100	7.0600	6.9600	NA	NA	NA	0.0	NA	NA	UNKNOWN	
0620	1	6.9400	6.9400	6.9400	NA	NA	NA	0.0	NA	NA	UNKNOWN	
POTASSIUM				MG/L								
0606	11	0.1300	10.3000	5.4000	5.6964	2.8640	0.5028	0.0	3.3096	8.0831	NORMAL	
0608	15	2.2000	5.0200	2.8000	2.9827	0.6633	0.2224	0.0	2.5333	3.4320	NORMAL	
0614	7	0.7200	1.9400	1.7000	1.6071	0.4328	0.2693	0.0	1.0930	2.1212	NORMAL	
0615	3	8.2000	18.0000	14.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	2.1000	2.5000	2.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	2.2000	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226				PCI/L								
0606	9	** 0.2000	0.7720	** 0.2000	** 0.2000	1.9977	NA	0.0	** 0.2000	0.2855	LOGNORMAL	7,8
0608	15	** 0.2000	1.3300	** 0.2000	NA	NA	NA	0.0	** 0.2000	0.3000	NONPARAMETRIC	9
0614	7	** 0.1000	1.9000	** 0.1000	NA	NA	NA	71.4	** 0.1000	1.9000	NONPARAMETRIC	2
0615	2	** 1.0000	1.2000	** 1.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	** 0.1000	0.2000	0.1000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	** 0.3000	** 0.3000	** 0.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226 + RADIUM-228				PCI/L								
0606	9	0.2000	1.4000	0.7000	0.7633	0.4285	0.5613	0.0	0.3497	1.1770	NORMAL	
0608	15	0.0000	6.2000	0.7000	NA	NA	NA	0.0	0.2000	1.3000	NONPARAMETRIC	9
0614	7	0.0000	6.9500	0.8500	NA	NA	NA	0.0	0.0000	6.9500	NONPARAMETRIC	9
0615	2	1.2400	4.1000	+ 2.6700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.5500	9.4000	1.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1.8000	1.8000	1.8000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-228				PCI/L								
0606	9	** 0.8000	1.3000	** 0.8000	NA	NA	NA	33.3	** 0.8000	1.3000	NONPARAMETRIC	2

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* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametric distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL				
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-228					PCI/L							
0608	15	** 0.9000	6.0000	** 0.9000	NA	NA	NA	40.0	** 0.9000	0.9000	NONPARAMETRIC	2
0614	7	** 1.0000	6.9000	** 1.0000	NA	NA	NA	14.3	** 1.0000	6.9000	NONPARAMETRIC	9
0615	2	** 1.0000	2.9000	+ 1.7000	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0618	3	** 1.0000	9.3000	1.1000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	1.7000	1.7000	1.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
REDOX POTENTIAL					mVOLTS							
0608	1	431.0000	431.0000	431.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0614	1	368.3000	368.3000	368.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	371.9000	371.9000	371.9000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	381.7000	381.7000	381.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM					MG/L							
0606	11	** 0.0010	0.0250	0.0060	NA	NA	NA	54.5	0.0010	0.0240	NONPARAMETRIC	2
0608	15	0.0010	0.0250	0.0140	NA	NA	NA	26.7	0.0050	0.0200	NONPARAMETRIC	2
0614	7	0.0025	0.0190	0.0030	NA	NA	NA	71.4	0.0025	0.0190	NONPARAMETRIC	2
0615	3	0.0050	0.0200	0.0070	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	0.0070	0.0150	0.0150	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SILVER					MG/L							
0606	11	** 0.0100	0.0200	** 0.0100	NA	NA	NA	72.7	** 0.0100	0.0200	NONPARAMETRIC	2
0608	15	** 0.0100	0.0200	** 0.0100	NA	NA	NA	86.7	** 0.0100	** 0.0100	NONPARAMETRIC	2
0614	7	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	** 0.0100	** 0.0100	NONPARAMETRIC	2
0615	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SODIUM					MG/L							
0606	11	0.1000	480.0000	29.0000	27.2971	8.2416	NA	0.0	4.7069	158.3065	LOGNORMAL	7,8

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1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SODIUM				MG/L								
0608	15	54.5000	108.0000	77.0000	82.0267	14.9601	0.1824	0.0	71.8910	92.1624	NORMAL	
0614	7	58.7000	83.5000	80.7000	76.6286	9.5937	0.1252	0.0	65.2318	88.0253	NORMAL	
0615	3	361.0000	510.0000	443.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	114.0000	117.0000	117.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	130.0000	130.0000	130.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SPECIFIC CONDUCTANCE				UMHO/CM								
0606	12	290.0000	2110.0000	+ 1250.0000	1328.6667	502.0022	0.3778	0.0	934.7862	1722.5472	NORMAL	
0608	15	100.0000	2330.0000	1200.0000	1306.3333	532.1066	0.4073	0.0	945.8238	1666.8429	NORMAL	
0614	7	1190.0000	2460.0000	1500.0000	1600.0000	405.0926	0.2532	0.0	1118.7734	2081.2266	NORMAL	
0615	4	360.0000	1700.0000	+ 1020.0000	1025.0000	609.8360	0.5950	0.0	-359.6327	2409.6327	NORMAL	
0618	3	1500.0000	1600.0000	1590.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1700.0000	1700.0000	1700.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
STRONTIUM				MG/L								
0606	1	1.2700	1.2700	1.2700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	3	1.0100	1.4000	1.1200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0614	2	0.7500	0.9000	+ 0.8250	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	1.3000	1.3000	1.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE				MG/L								
0606	11	** 0.1000	1760.0000	1080.0000	1062.4591	470.8911	0.4432	9.1	670.0291	1454.8891	NORMAL	
0608	15	524.0000	1010.0000	848.0000	841.4667	123.0731	0.1463	0.0	758.0830	924.8504	NORMAL	
0614	7	661.0000	1042.0000	982.0000	911.8571	149.9705	0.1645	0.0	733.7009	1090.0134	NORMAL	
0615	3	720.0000	1220.0000	1120.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	948.0000	1020.0000	1020.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1090.0000	1090.0000	1090.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFIDE				MG/L								
0606	5	** 0.0800	0.0800	** 0.0800	NA	NA	NA	80.0	** 0.0800	0.0800	NONPARAMETRIC	2,5
0608	7	** 0.1000	6.8000	** 0.1000	NA	NA	NA	85.7	** 0.1000	6.8000	NONPARAMETRIC	2

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS										
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFIDE					MG/L							
0614	5	** 0.1000	119.0000	** 0.1000	NA	NA	NA	60.0	** 0.1000	119.0000	NONPARAMETRIC	2,5
0615	3	0.0200	7.6000	0.0500	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	2	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.1000	** 0.1000	** 0.1000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TEMPERATURE					C - DEGREE							
0606	12	7.0000	23.4000	+ 9.0000	10.3000	4.2414	0.4118	0.0	6.9722	13.6278	NORMAL	
0608	15	8.7000	13.8000	9.5000	9.7933	1.2853	0.1312	0.0	8.9225	10.6642	NORMAL	
0614	7	9.0000	12.0000	10.5000	10.4857	0.9907	0.0945	0.0	9.3089	11.6626	NORMAL	
0615	4	6.0000	14.0000	+ 10.5000	10.2500	3.3040	0.3223	0.0	2.7482	17.7518	NORMAL	
0618	3	10.0000	11.1000	11.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	11.0000	11.0000	11.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
THALLIUM					MG/L							
0606	5	** 0.0010	0.0500	0.0050	NA	NA	NA	100.0	** 0.0010	0.0500	NONPARAMETRIC	2,5
0608	9	** 0.0010	0.0500	0.0050	NA	NA	NA	100.0	** 0.0010	0.0500	NONPARAMETRIC	2
0614	6	** 0.0100	0.0150	** 0.0100	NA	NA	NA	100.0	** 0.0100	0.0150	NONPARAMETRIC	2,6
0615	3	** 0.0010	0.0500	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0150	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0300	** 0.0300	** 0.0300	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
THORIUM-230					PCI/L							
0606	1	** 0.6000	** 0.6000	** 0.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	2	** 0.7000	** 0.7000	** 0.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TIN					MG/L							
0606	5	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	** 0.0050	** 0.0050	NONPARAMETRIC	2,5
0608	8	** 0.0050	0.0150	** 0.0050	NA	NA	NA	100.0	** 0.0050	0.0150	NONPARAMETRIC	2
0614	6	** 0.0050	0.0250	** 0.0050	NA	NA	NA	100.0	** 0.0050	0.0250	NONPARAMETRIC	2,6
0615	3	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TIN				MG/L								
0618	3	** 0.0050	0.0250	0.0125	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	** 0.0500	** 0.0500	** 0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS				MG/L								
0606	11	** 10.0000	2850.0000	1980.0000	1907.0000	751.3395	0.3940	9.1	1280.8507	2533.1493	NORMAL	
0608	15	1270.0000	1810.0000	1610.0000	1611.2000	149.0116	0.0925	0.0	1510.2426	1712.1574	NORMAL	
0614	6	1350.0000	3760.0000	+ 1810.0000	2000.0000	897.7750	0.4489	0.0	766.6767	3233.3233	NORMAL	
0615	3	1750.0000	2108.0000	1880.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	1840.0000	1970.0000	1960.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	2090.0000	2090.0000	2090.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON				MG/L								
0606	1	27.0000	27.0000	27.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	4	** 1.0000	39.3000	+ 4.5000	NA	NA	NA	25.0	** 1.0000	39.3000	NONPARAMETRIC	2,4
0614	1	16.0000	16.0000	16.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0615	1	31.0000	31.0000	31.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	9.0000	9.0000	9.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM				MG/L								
0606	11	** 0.0003	0.0140	0.0063	NA	NA	NA	18.2	0.0015	0.0103	NONPARAMETRIC	2
0608	15	0.0005	0.0053	0.0030	NA	NA	NA	20.0	0.0015	0.0045	NONPARAMETRIC	2
0614	7	** 0.0010	0.0060	0.0040	0.0037	0.0018	0.4875	14.3	0.0016	0.0059	NORMAL	
0615	3	0.0220	0.0870	0.0340	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.0010	0.0046	0.0030	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.0030	0.0030	0.0030	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
VANADIUM				MG/L								
0606	6	** 0.0100	0.0500	** 0.0100	NA	NA	NA	66.7	** 0.0100	0.0500	NONPARAMETRIC	2,6
0608	9	** 0.0100	0.0400	** 0.0100	NA	NA	NA	55.6	** 0.0100	0.0400	NONPARAMETRIC	2
0614	6	** 0.0100	0.0200	** 0.0100	NA	NA	NA	66.7	** 0.0100	0.0200	NONPARAMETRIC	2,6

** The reported value is the minimum detection limit of the data set
+ The sample size is even, so the median value is the arithmetic average of the two middle values
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

TABLE 3.12 - DOWNGRADIENT ALLUVIAL MONITOR WELLS, GROUNDWATER QUALITY
STATISTICS BY PARAMETER, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME					UNITS											
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM					MG/L							
0615	3	** 0.0100	0.0100	** 0.0100	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	** 0.0100	0.0200	** 0.0100	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	** 0.0100	** 0.0100	** 0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ZINC					MG/L							
0606	9	** 0.0050	0.0300	0.0110	NA	NA	NA	22.2	** 0.0050	0.0300	NONPARAMETRIC	2
0608	13	** 0.0050	0.0120	** 0.0050	NA	NA	NA	61.5	** 0.0050	0.0110	NONPARAMETRIC	2
0614	7	** 0.0050	0.0110	** 0.0050	NA	NA	NA	71.4	** 0.0050	0.0110	NONPARAMETRIC	2
0615	3	** 0.0050	0.0200	0.0060	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	** 0.0050	0.0070	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	** 0.0050	** 0.0050	** 0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

** The reported value is the minimum detection limit of the data set
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: M:\DART\DUR03\GW010012.DAT

The number of exceedances of MCLs for each alluvial monitor well since seep appearance are shown in Table 3.13. These exceedances occur once or twice in each monitor well during the three and half year period of interest, except for selenium, which occurs seven times in monitor well 608. Chromium and lead concentrations have not exceeded MCLs in any downgradient monitor well since 1988. Molybdenum, net gross alpha, and radium-226 and -228 have also exceeded MCLs at least once in background alluvial monitor well 623 (Table 3.13). This indicates that concentrations greater than MCLs for these constituents occur naturally in the alluvial groundwater.

Table 3.13 shows that selenium concentrations in monitor well 623 appear to have exceeded MCLs twice in 1990 and once in 1991. However, these three samples had high laboratory method detection limits due to interference and dilution, and the selenium concentrations were less than the detection limits. Therefore, all selenium concentrations in background monitor well 623 were below laboratory method detection limits. This indicates that the exceedances of the MCL for selenium observed in downgradient alluvial monitor wells 606, 608, 614, 618, and 620 are probably due to discharges from the retention pond to the arroyo. The selenium exceedances observed in monitor well 615 are probably due to the seep on the east face of the disposal cell, which appeared in October 1988.

Standard EPA (EPA, 1989) statistical methods and analyses were utilized in this investigation. To confirm whether the presence of the hazardous constituents represents alluvial groundwater contamination in areas monitored by specific wells, the maximum observed concentrations and the lower limit of the 98 percent confidence interval for the constituents for each monitor well during the same period were also compared with the MCLs (Table 3.12). Maximum observed concentrations or activities of chromium, lead, and radium-226 and -228 exceeded MCLs only in downgradient alluvial monitor wells northeast of the disposal cell (monitor wells 606, 608, 614, and 618). Maximum observed concentrations or activities of net gross alpha, molybdenum, and selenium exceeded MCLs in monitor wells northeast of the disposal cell and east of the disposal cell (monitor wells 606, 608, 614, 615, and 618). Maximum observed concentrations of uranium exceeded MCLs only in monitor well 615 east of the disposal cell. The median selenium concentration in monitor well 608 exceeded the MCL. Therefore, selenium contamination in the alluvial groundwater in the area of monitor well 608 is possible. However, the lower limit of the 98 percent confidence interval did not exceed the MCLs for any of the hazardous constituents, including selenium, in any monitor well. Therefore, there is no statistical evidence that they are groundwater contaminants that exceed the MCLs at the 98 percent confidence interval.

For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater was compared to the statistical maximum for background groundwater quality (Table 3.10). If statistical maxima were not available for certain parameters

TABLE 3.13 - ALLUVIUM MONITOR WELLS, GROUNDWATER CONCENTRATION DATA
EXCEEDING MCLs, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAXIMUM CONC. LIMIT	LOC. ID	LOG DATE	SAMP ID	FORM OF COMP	HYDR FLOW REL.	RESULT EXCEEDING MAX. CONCENTRATION LIMIT VALUE	FLAGS	DETECTION LIMIT	PARAMETER UNCERT.
ARSENIC	47	MG/L	0.0500	-	-	-	-	-	-		-	-
ARSENIC (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
BARIUM	41	MG/L	1.0000	-	-	-	-	-	-		-	-
BARIUM (TOTAL)	0	MG/L	1.0000	-	-	-	-	-	-		-	-
CADMIUM	47	MG/L	0.0100	-	-	-	-	-	-		-	-
CADMIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-		-	-
CHROMIUM	43	MG/L	0.0500	0606	04/07/88	0001	AL	D	0.13		0.01	-
				0606	10/09/88	0001	AL	D	0.09		0.01	-
				0608	04/07/88	0001	AL	D	0.09		0.01	-
				0608	10/09/88	0001	AL	D	0.08		0.01	-
CHROMIUM (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
GROSS ALPHA	38	PCI/L	15.0000	0606	04/07/88	0001	AL	D	< 15.	b	0.2	15.
				0606	04/05/89	0001	AL	D	69.		0.2	24.
				0606	07/15/89	0001	AL	D	26.		0.2	16.
				0608	11/16/89	0001	AL	D	19.		1.0	12.
				0614	07/18/90	0001	AL	D	29.3		1.0	15.1
				0614	08/31/90	0001	AL	D	38.2		1.0	18.8
				0615	11/21/89	0001	AL	D	46.		1.0	15.
				0615	01/07/90	0001	AL	D	29.3		1.0	16.2
				0623	07/19/90	0001	AL	U	23.8		1.0	15.6
GROSS ALPHA (TOTAL)	0	PCI/L	15.0000	-	-	-	-	-	-		-	-
LEAD	43	MG/L	0.0500	0608	10/09/88	0001	AL	D	0.06		0.01	-
LEAD (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
MERCURY	46	MG/L	0.0020	-	-	-	-	-	-		-	-

< - THE DATA IS FLAGGED AS A NON-DETECT, SO THE RESULT IS AN ESTIMATED VALUE OR THE DETECTION LIMIT

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

OTHER PARAMETER VALUE FLAGS:
b - CHANGED PARAMETER VALUE

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

TABLE 3.13 - ALLUVIUM MONITOR WELLS, GROUNDWATER CONCENTRATION DATA
EXCEEDING MCLs, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAXIMUM CONC. LIMIT	LOC. ID	LOG DATE	SAMP ID	FORM OF COMP	HYDR FLOW REL.	RESULT EXCEEDING MAX. CONCENTRATION LIMIT VALUE	FLAGS	DETECTION LIMIT	PARAMETER UNCERT.
MERCURY (TOTAL)	0	MG/L	0.0020	-	-	-	-	-	-		-	-
MOLYBDENUM	47	MG/L	0.1000	0606	11/23/87	0001	AL	D	0.20		0.01	-
				0608	02/22/90	0001	AL	D	0.1		0.01	-
				0615	10/25/89	0001	AL	D	0.102		0.01	-
				0623	02/22/90	0001	AL	U	0.2		0.01	-
MOLYBDENUM (TOTAL)	0	MG/L	0.1000	-	-	-	-	-	-		-	-
NET GROSS ALPHA *	38	PCI/L	15.0000	0606	04/05/89	0001	AL	D	63.7		-	-
				0606	07/15/89	0001	AL	D	22.1		-	-
				0608	11/16/89	0001	AL	D	16.2		-	-
				0614	07/18/90	0001	AL	D	27.2		-	-
				0614	08/31/90	0001	AL	D	37.9		-	-
				0615	11/21/89	0001	AL	D	30.9		-	-
				0623	07/19/90	0001	AL	U	22.4		-	-
NET GROSS ALPHA (TOTAL) **	0	PCI/L	15.0000	-	-	-	-	-	-		-	-
NITRATE	43	MG/L	44.0000	-	-	-	-	-	-		-	-
NITRATE (TOTAL)	0	MG/L	44.0000	-	-	-	-	-	-		-	-
RA-226 & RA-228	44	PCI/L	5.0000	0608	04/23/91	0001	AL	D	6.2		-	-
				0614	08/31/90	0001	AL	D	7.0		-	-
				0618	08/31/90	0001	AL	D	9.4		-	-
				0623	10/27/89	0001	AL	U	35.4		-	-
RA-226 & RA-228 (TOTAL)	0	PCI/L	5.0000	-	-	-	-	-	-		-	-
SELENIUM	47	MG/L	0.0100	0606	10/09/88	0001	AL	D	0.012		0.005	-
				0606	04/05/89	0001	AL	D	0.024		0.005	-
				0606	08/08/91	0001	AL	D	< 0.05	I	0.05	-

< - THE DATA IS FLAGGED AS A NON-DETECT, SO THE RESULT IS AN ESTIMATED VALUE OR THE DETECTION LIMIT

* NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
** TOTAL NET GROSS ALPHA (TOTAL GROSS ALPHA - TOTAL URANIUM)

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

OTHER PARAMETER VALUE FLAGS:
I - INTERFERENCE-DILUTION OF SAMPLE

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

TABLE 3.13 - ALLUVIUM MONITOR WELLS, GROUNDWATER CONCENTRATION DATA
EXCEEDING MCLs, BODO CANYON DISPOSAL SITE, COLORADO
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME	TOTAL # OF SAMP.	UNITS OF MEASURE	MAXIMUM CONC. LIMIT	LOC. ID	LOG DATE	SAMP ID	FORM OF COMP	HYDR FLOW REL.	RESULT EXCEEDING MAX. CONCENTRATION LIMIT VALUE	FLAGS	DETECTION LIMIT	PARAMETER UNCERT.
SELENIUM	47	MG/L	0.0100	0608	10/09/88	0001	AL	D	0.017		0.005	-
				0608	01/08/89	0001	AL	D	0.014		0.005	-
				0608	04/04/89	0001	AL	D	0.023		0.005	-
				0608	07/15/89	0001	AL	D	0.014		0.005	-
				0608	10/26/89	0001	AL	D	0.02		0.005	-
				0608	11/16/89	0001	AL	D	0.019		0.005	-
				0608	01/05/90	0001	AL	D	< 0.03	I	0.03	-
				0608	02/22/90	0001	AL	D	< 0.01	I	0.01	-
				0608	10/30/90	0001	AL	D	.013		0.005	-
				0608	08/08/91	0001	AL	D	< 0.05	I	0.05	-
				0614	11/21/89	0001	AL	D	0.019		0.005	-
				0614	07/18/90	0001	AL	D	< 0.03		0.03	-
				0614	08/31/90	0001	AL	D	< 0.03	I	0.03	-
				0615	10/25/89	0001	AL	D	0.02		0.005	-
				0615	01/07/90	0001	AL	D	< 0.01	I	.01	-
				0618	07/17/90	0001	AL	D	< 0.03		0.03	-
				0618	08/31/90	0001	AL	D	< 0.03	I	0.03	-
				0620	07/17/90	0001	AL	D	< 0.03		0.03	-
				0623	02/22/90	0001	AL	U	< 0.01	I	0.01	-
				0623	07/19/90	0001	AL	U	< 0.03		0.03	-
				0623	08/07/91	0001	AL	U	< 0.05	I	0.05	-
SELENIUM (TOTAL)	0	MG/L	0.0100	-	-	-	-	-	-		-	-
SILVER	47	MG/L	0.0500	-	-	-	-	-	-		-	-
SILVER (TOTAL)	0	MG/L	0.0500	-	-	-	-	-	-		-	-
URANIUM	47	MG/L	0.0440	0615	10/25/89	0001	AL	D	.087		0.003	0.009
URANIUM (TOTAL)	0	MG/L	0.0440	-	-	-	-	-	-		-	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

OTHER PARAMETER VALUE FLAGS:
I - INTERFERENCE-DILUTION OF SAMPLE

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

DATA FILE NAME: M:\DART\DUR03\GWQ10017.DAT

because there were fewer than four samples, comparisons were made with background observed maxima. Maximum observed copper concentrations exceeded the statistical maximum for background in monitor wells 606 and 608. Maximum observed cyanide and fluoride concentrations exceeded the statistical maxima for background in monitor wells 618 and 615, respectively. Maximum observed vanadium concentrations exceeded the statistical maximum for background in monitor wells 606 and 608.

Table 3.12 shows the maximum observed sulfide concentration in monitor well 614 at 119 mg/l. However, the validity of this sample is discounted since the holding time was exceeded and seven previous samples from monitor well 614 were nondetect for sulfide. Cyanide was not observed in background groundwater, yet exceeded laboratory detection limits in monitor well 615. However, cyanide was not observed above detection limits in any tailings pore fluid samples (Calculation DUR-03-09-90-15-01-00). Therefore, cyanide cannot be a groundwater contaminant related to the disposal cell. Fluoride is an element of a hazardous constituent compound, carbon oxyfluoride, which does not exist in water. Therefore, in groundwater this element is not considered a hazardous constituent.

The criteria of exceedance of the statistical maximum was used to determine whether copper and vanadium should undergo further statistical analysis as they may be considered potential groundwater contaminants. Since more than 50 percent of the vanadium data from downgradient monitor wells and upgradient monitor well 623 indicate concentrations below detection, but at least 10 percent of the observations are quantified, a test of proportions was used to determine if vanadium is a groundwater contaminant (Calculation DUR-03-02-91-13-11). In the test of proportions for vanadium, there was no statistically significant evidence at the five percent significance level that vanadium is a groundwater contaminant in either downgradient monitor well 605 or 608.

Since more than 50 percent of the copper data from downgradient monitor wells and upgradient monitor well 623 indicate concentrations below detection, but at least 10 percent of the observations are quantified, a test of proportions was used to determine if copper is a groundwater contaminant (Calculation DUR-03-02-91-13-11). In the test of proportions for copper, there was no statistically significant evidence at the five percent significance level that copper is a groundwater contaminant in either downgradient monitor well 605 or 608.

In summation, there is no statistical evidence that the hazardous constituents chromium, copper, lead, molybdenum, net gross alpha, radium-226 and -228, uranium, and vanadium are groundwater contaminants in the alluvial groundwater. The median selenium concentration in monitor well 608 exceeded the MCL. Therefore, selenium contamination in the alluvial groundwater in the area of monitor well 608 is possible.

A selenium concentration versus time plot was created for monitor well 608 (Figure 3.16). This was done to determine by inspection if selenium concentrations are increasing or decreasing with time and to determine if future concentrations could be predicted based upon any observed concentration changes with time. The known retention pond discharge dates are also indicated in this figure. Selenium concentrations in monitor well 608 (Figure 3.6 and Table 3.14) are representative of background water quality prior to October 1988, yet exceeded MCLs from October 1988 through November 1989. The January and February 1990 water samples from monitor well 608 had interference problems and the actual concentrations are less than the values shown (Table 3.14). Monitor well 608 did not produce enough water to sample from March through September 1990. In October 1990, selenium concentrations again exceeded MCLs. In April 1991, the selenium concentration was just below the MCL. In summary, selenium concentrations observed in monitor well 608 exceeded the MCL after the seep appearance on the east face of the disposal cell. A least-squares-spline best-fit line through the selenium data indicates that selenium concentrations show no definite increase or decrease in concentration with time (Figure 3.16).

3.2.7 Geochemical conditions

Geochemical investigations were undertaken at the Durango disposal site for the following reasons:

1) To characterize the geochemical environment beneath the disposal cell.

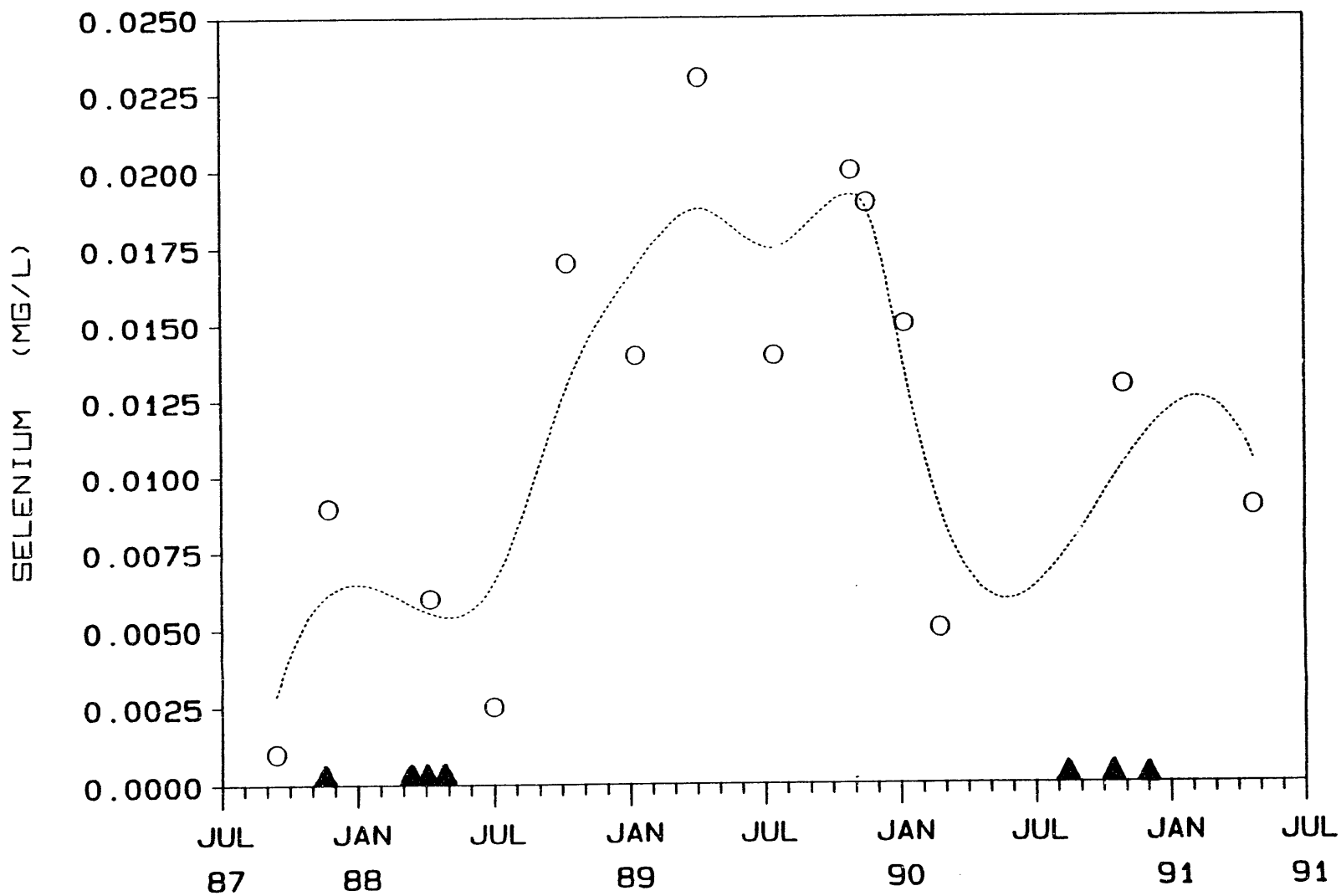
2) To characterize the attenuation capacity of subpile sediments with regard to hazardous constituents in the tailings.

3) To determine if tailings fluid has infiltrated into the underlying scarified soil liner since placement of the tailings at the disposal site.

4) To determine the physiochemical conditions of groundwater within the Cliff House and Menefee Formations and the potential for attenuation of hazardous constituents.

Characterization of geochemical environment

In 1989, the DOE collected core samples from the alluvium/weathered shale. These samples were sent to a lab for physical, chemical, and mineralogical characterization. Sediments collected from the subsurface in the vicinity of the disposal cell were divided into four categories based on gross physical characteristics. Table 3.15 lists the borehole number, sample depth, and grain size distribution for each sample. The subsurface sediments, as defined by the Unified Soil Classification System, fall within the inorganic silt category. The tailings at Durango were depleted of fine-grained particles during milling and are classified as a poorly graded sand. Table 3.16 is a listing of the mineralogy of the



LEGEND

▲ RETENTION POND DISCHARGES

NOTE: DISCHARGES ALSO OCCURRED IN 1989; HOWEVER, DATES ARE UNAVAILABLE

FIGURE 3.16
SELENIUM CONCENTRATION VERSUS TIME
MONITOR WELL 608

TABLE 3.14 - DOWNGRADIENT ALLUVIUM MONITOR WELL 608, SELENIUM CONCENTRATION DATA
SITE: DUR03 BODO CANYON
09/13/87 TO 08/08/91
REPORT DATE: 12/17/91

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PVI	PARAMETER VALUE	FLAGS	DETECTION LIMIT	PARAMETER UNCERTAINTY
SELENIUM	0608	09/13/87	0001	AL	D	MG/L		0.001	c	0.001	-
	0608	11/23/87	0001	AL	D			0.009		0.005	-
	0608	04/07/88	0001	AL	D			0.006		0.005	-
	0608	07/01/88	0001	AL	D		<	0.005		0.005	-
	0608	10/09/88	0001	AL	D			0.017		0.005	-
	0608	01/08/89	0001	AL	D			0.014		0.005	-
	0608	04/04/89	0001	AL	D			0.023		0.005	-
	0608	07/15/89	0001	AL	D			0.014		0.005	-
	0608	10/26/89	0001	AL	D			0.02		0.005	-
	0608	11/16/89	0001	AL	D			0.019		0.005	-
	0608	01/05/90	0001	AL	D		<	0.03	I	0.03	-
	0608	02/22/90	0001	AL	D		<	0.01	I	0.01	-
	0608	10/30/90	0001	AL	D			.013		0.005	-
	0608	04/23/91	0001	AL	D			0.009		0.005	-
	0608	08/08/91	0001	AL	D		<	0.05	I	0.05	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

OTHER PARAMETER VALUE FLAGS:
I - INTERFERENCE-DILUTION OF SAMPLE
c - CHANGED DETECTION LIMIT

DATA FILE NAME: M:\DART\DUR03\GWQ10014.DAT

Table 3.15 Grain size distribution of subpile sediments, Bodo Canyon disposal site, Colorado (PMET, 1989)

Borehole no.	Depth (ft)	Material[a]	Grain size distribution		
			Sand (+63 micron)	Silt (-63+5 micron)	Clay (-5 micron)
615	3 - 10	GC	30.01 wt. %	34.94 wt. %	35.05 wt. %
618	40 - 43	ML	38.42 wt. %	31.52 wt. %	30.06 wt. %
620	34 - 37	CL	32.58 wt. %	34.48 wt. %	32.94 wt. %
623	21 - 30	ML	33.72 wt. %	32.81 wt. %	33.47 wt. %
Tailings	Surface	SW	80.89 wt. %	8.34 wt. %	10.76 wt. %

[a]Description per Unified Soil Classification System.

Table 3.16 Mineralogy of sub-disposal-cell sediments and tailings, Bodo Canyon disposal site, Colorado (PMET, 1989)

Mineral	Sample no. and concentration[a] (% volume)				
	615	618	620	623	Tailings
Siliceous gangue[b]	≥50	≥50	40-50	40-50	≥50
FeOX[c]	5-10	15-20	10-15	10-20	5-10
Clay minerals[d]	12-20	10-15	5-8	8-10	4-6
Rock fragments	2-3	2-3	<1	1-2	10-12
Heavy minerals	≥10	5-8	5-10	5-8	5-8
Carbonates	2-3	4-6	10-12	<1	<1
Coarse mica	5-8	8	8-10	8-10	5
Sulfides[e]	3	2	3	3	1
Gypsum	-	-	-	<1	<1

[a]Determined by modal analyses of polished sections, and dry and oil immersion grain mounts.
[b]Indicates quartz, feldspar, and amorphous silica.
[c]Iron oxidation products, intimately mixed with clays.
[d]Micaceous clay minerals.
[e]Primarily pyrite with traces of chalcopyrite.

subpile sediments and tailings (semi-quantitative). Table 3.17 is a compilation of the chemical characteristics of these same samples. Quartz, amorphous silica, and feldspar are the dominant minerals in all samples. The geochemistry of these sediments is controlled by the minor and trace minerals. While up to 35 weight percent of the sediment is clay-sized particles, only about 10-20 volume percent is actually clay minerals. Table 3.18 is a compilation of the types of clays found in the -2 micron fraction. Kaolinite, illite, and fine-grained muscovite are the major sheet silicates. Smectites and, specifically, montmorillonite are listed as minor and trace minerals. The dominant clays are of the non-reactive type, so these sediments have very low cation exchange capacities. This geochemical analysis indicates that sub-disposal cell sediments at Bodo Canyon will have little attenuation capacity for the hazardous constituents that migrate in groundwater as cations (for example, cadmium, zinc, and cobalt).

Pore fluids were collected from the tailings piles at their former location on the processing site. Groundwater samples from alluvial monitor wells placed near the piles had neutral pH. The sub-disposal cell sediments in Bodo Canyon, with the exception of sample 620, have very low potential acidity and acid neutralizing capability (Table 3.17). Sample 620 has a relatively high carbonate content (about 10 volume percent) and this gives it a relatively high acid neutralization capacity (45 tons calcium carbonate per 1000 tons soil). The only indication that acidity could be a problem for tailings disposal is in a report on the hydrogeochemical characterization of the processing site (BFEC, 1983). This report includes data that indicate that the mill raffinate had a pH of 0.8. Because material in the bottom of the raffinate ponds was included in the tailings embankment, there is a potential for some high-acidity fluids to leak through the foundation layer. The small amount of low-pH material and the presence of the high-carbonate layer under at least some of the pile should protect the subsurface from damage by acidic solutions. The pH of samples from tailings monitor wells ranges from 6.3 to 7.6, and averages 6.7 (Table 3.19). Also, the pH of the effluent from the disposal cell toe drain ranges from 7.2 to 8.3, and averages 7.7 (Table 3.19). This suggests that the acidic materials are well mixed and buffered by the other tailings material.

All of the sub-disposal cell sediments contain very little sulfur either as sulfide or sulfate. The lack of reduced sulfur explains the very low potential acidity of the sediments. The sediments contain greater than one weight percent acid-soluble iron and very little acid-soluble manganese (<0.1 weight percent). These values indicate that the sediments are totally oxidized and will have little retention capacity for those hazardous constituents that precipitate under reducing conditions such as arsenic, molybdenum, selenium, and uranium. Agricultural research has shown that the presence of acid-soluble iron oxides (limonite and goethite) can cause the binding of elements that are present in groundwaters as oxyanions (for example, phosphate and sulfate). Several of the hazardous constituents associated with mill tailings are present in groundwaters as oxyanions: selenium, arsenic, and molybdenum. These elements should be attenuated through surface complexation with iron oxide minerals in the Bodo Canyon sediments.

Table 3.17 Chemical characterization of soil samples, Bodo Canyon disposal site, Colorado

Element	Sample designations				
	615	618	620	623	Tailings
Total carbon, %	0.46	0.25	0.59	0.10	0.06
Carbonate carbon, %	0.12	0.12	0.55	0.03	0.03
Organic carbon, %	0.34	0.13	0.04	0.07	0.03
Total sulfur, %	<0.02	<0.02	<0.02	<0.02	0.15
Sulfide, %	<0.02	<0.02	<0.02	<0.02	<0.02
Sulfate, %	<0.05	<0.05	<0.05	<0.05	0.15
Hydrochloric acid soluble iron, %	1.9	1.4	1.2	1.6	1.3
Hydrochloric acid soluble manganese, %	0.023	0.010	0.012	0.013	0.024
pH	7.51	8.01	7.78	7.95	7.44
Cation exchange capacity[a]	16.5	8.59	7.70	8.59	2.03
Neutraliz. potential (Tons calcium carbonate/1000 tons soil)	8.79	12.5	45.2	3.64	4.02
Potential acidity (Tons hydrogen ion/100 tons soil)	0.11	0.06	0.05	0.05	<0.01

[a]In milliequivalents per 100 grams.

Table 3.18 Semi-quantitative clay mineralogy, Bodo Canyon disposal site, Colorado (PMET, 1989)

Sample	Major[a]	Frequency minor[a]	Trace[a]
615	Illite Muscovite Kaolinite	Smectite-mica	Montmorillonite
618	Kaolinite Muscovite	Illite	Smectite-mica
620	Illite Kaolinite	Smectite-mica Muscovite	Chlorite-mica
623	Muscovite Kaolinite	Illite	Smectite-mica
Tailings	Kaolinite	Kaolinite	Smectite-mica Illite

[a]-2 micron fraction.

Determination of attenuation capacity of Bodo Canyon sediments

Batch tests were conducted using core samples of the previously identified categories of unconsolidated sediments (Table 3.16) and tailings pore fluids collected from a toe drain that was installed in the disposal cell in order to determine the attenuation capacity of the sub-disposal cell sediments. Aliquots of the subsurface samples were added to tailings pore fluid and the attenuation capacities for individual chemical species were determined. Because the sub-disposal cell sediments are very fine grained and of low permeability, it was necessary to conduct the chemical attenuation tests as batch tests and not as column tests. The batch test procedure used by the UMTRA Project has been modified from Method 4319 of the American Society for Testing and Materials (ASTM).

Tailings pore fluid was collected, analyzed, and used as a test solution. The attenuation capacity varies for each hazardous constituent in the tailings pore fluid. Under the physiochemical conditions of these batch experiments (neutral pH and oxidizing), the hazardous constituents are present as different species. Arsenic, molybdenum, and selenium are all present as oxyanions (arsenate, molybdate, and selenite).

The results of the batch tests indicate that less than 10 percent of the molybdenum is adsorbed, most of the arsenic and vanadium (about 80 percent and 65 percent, respectively) is adsorbed, and about 30 percent of the selenium is adsorbed. Uranium is present in solution as a uranyl-carbonate complex anion and from 10 to 20 percent of the uranium is adsorbed onto the sediments. These anions and anionic complexes are competing for adsorption sites with sul-

TABLE 3.19 - TAILINGS MONITOR WELLS (200 -204) AND DISPOSAL CELL TOE DRAIN (638), PH DATA
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 12/18/91

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
PH	0200	12/01/88	0001	TA	O	SU		6.83		-
	0200	01/08/89	0001	TA	O			6.67		-
	0200	04/05/89	0001	TA	O			6.51		-
	0201	12/01/88	0001	TA	O			6.40		-
	0201	01/08/89	0001	TA	O			6.29		-
	0201	04/05/89	0001	TA	O			6.29		-
	0202	12/01/88	0001	TA	O			6.76		-
	0202	01/08/89	0001	TA	O			6.56		-
	0202	04/04/89	0001	TA	O			6.43		-
	0203	12/01/88	0001	TA	O			7.57		-
	0203	01/08/89	0001	TA	O			7.43		-
	0203	04/04/89	0001	TA	O			7.29		-
	0204	12/01/88	0001	TA	O			6.76		-
	0204	01/08/89	0001	TA	O			6.63		-
	0204	04/04/89	0001	TA	O			6.44		-

FORMATION OF COMPLETION CODE:
TA - URANIUM MILL TAILINGS

FLOW RELATIONSHIP CODE:
O - ON-SITE

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

DATA FILE NAME: M:\DART\DUR03\GWQ10015.DAT

02/22/90 TO 09/21/90
REPORT DATE: 12/18/91

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	UNITS OF MEASURE	PARAMETER PVI	VALUE	FLAGS	PARAMETER UNCERTAINTY
PH	0638	02/22/90	0001	SU		7.65		-
	0638	02/22/90	N001			7.65		-
	0638	04/27/90	N001			8.27		-
	0638	07/17/90	0001			7.17		-
	0638	09/21/90	0001			8.06		-

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)
N001 - UNFILTERED SAMPLE

DATA FILE NAME: M:\DART\DUR03\SWQ10002.DAT

fate that is present at 1,000 times higher concentration. The wide range in adsorption capacities among the oxyanions seems to indicate that there are distinctions among the adsorption sites that can contain these species. From these tailings solutions, arsenic, molybdenum, uranium, and selenium are usually left in solution at concentrations that exceed their MCLs. The only hazardous constituents that exist in the tailings fluids as cations and are present at concentrations in excess of the detection limit are cadmium (Cd^{2+}), and vanadium (VO^{2+}). All four sediment samples removed cadmium to concentrations below the MCL (0.01 mg/l).

Vanadium is a hazardous constituent that is contained within minerals with relatively high solubilities. Even under the relatively reducing conditions at the downgradient edge of the cell, vanadium will still be present in solution in concentrations in excess of background. Batch attenuation tests on the sub-disposal cell sediments indicate that from 66 to 85 percent of the vanadium in solution is taken up by these sediments. Calculation DUR-09-90-13-06-00 indicates that using the least conservative attenuation capacity (0.030 mg/g) and assuming a veneer of sediments 30 feet thick, also a conservative estimate, will provide a 20 times excess capacity for the amount of fluid expected to infiltrate through the sediment column in 1000 years. Surface complexation on iron oxyhydroxides is the hypothesized mechanism causing the attenuation of vanadium.

In summary, the attenuation batch experiments indicate that the subsurface sediments beneath the Bodo Canyon disposal cell will adsorb all of the vanadium, a majority of the arsenic in solution, a lesser amount of selenium and uranium, and a small amount of the molybdenum. These sediments will also adsorb those constituents that are present as cations.

EPA 3050 method analyses of the scarified liner

When the foundation of the disposal cell was being prepared, approximately two feet of the soil and sediment was scarified and recompacted to act as a basal liner. During construction, a significant amount of water was added to the tailings for dust control and in order to reach the specified compaction. Some of the construction water infiltrated through the tailings and perched on a less permeable layer of vicinity property (VP) materials that had been used as a temporary cover between construction seasons. A toe drain designed to discharge this construction water was excavated at the northeast face of the disposal cell in 1989. During the excavation of this toe drain, samples of the foundation layer were collected for chemical analysis. A core sample of the liner was collected in order to determine whether infiltrating tailings fluids had deposited hazardous constituents within these materials and whether the distribution of the hazardous constituents could provide insight into the amount of constituents that the sediments could attenuate. The core was divided into four samples based upon depth from the tailings liner interface. The uppermost sample was located

from four to seven inches below the interface, the next at seven to 10 inches, the third at 12 to 15 inches, and the lowermost at 15 to 18 inches. The samples were digested in a nitric acid reflux according to EPA method 3050 and the extractant was analyzed via the EPA methods for inorganic constituents. Table 3.20 is a list of the analytical data from these samples. With the exception of selenium and zinc, all of the constituents are homogeneously distributed throughout the liner. The distribution of constituents is believed to be a function of the natural composition of the liner materials. Therefore, it appears that tailings pore fluids have not yet infiltrated the liner material.

Batch leach tests on the scarified liner

Batch tests (ASTM method 4319) were conducted using core samples of the unconsolidated sediments and distilled water to determine whether tailings fluids had leached into the underlying scarified soil liner beneath the disposal cell. The core samples were homogenized and divided into aliquots. At the conclusion of the test, the liquids were filtered to remove suspended solids, pH and alkalinity were measured, and the liquid samples were shipped to an analytical laboratory. In order to determine the natural contribution of hazardous constituents from the sediments to groundwater, each of the solids were leached with double distilled water. Table 3.21 indicates that concentrations of the hazardous constituents in these sediment leachates are all below their detection limits. Tables 3.22 and 3.23 contain the influent and effluent concentrations and their ratios for the two series of batch tests. A comparison of the data in Table 3.21 with those in Tables 3.22 and 3.23 indicates that most hazardous constituents in the soil samples from the scarified liner are at least an order of magnitude lower in concentration than those found in the overlying tailings pore fluids. It is concluded that tailings fluids have not yet penetrated the underlying sediments at the sample locations beneath the disposal cell.

Determination of the physiochemical conditions within the Cliff House and Menefee Formations

In order to investigate the physiochemical conditions in the monitor wells within the underlying Cliff House and Menefee Formations, the DOE collected field measurements of pH and redox potential in 1990. The measured Eh in the updip monitor well 605 is 205 millivolts, in the cross gradient monitor well 616 is 129 millivolts, and in the downgradient monitor well 607 is -30 millivolts. The pH values for these wells are 6.50, 6.21, and 6.41, respectively.

Geochemical simulations of theoretical redox potentials were made for dissolved oxygen and the following redox couples: ferrous/ferric iron, nitrate/ammonium, sulfate/bisulfide, and rhombic sulfur/bisulfide (Calculation DUR-09-90-14-14(01)-00). The predicted

Table 3.20 Elemental concentrations in disposal cell underliner, Bodo Canyon disposal site, Colorado

Parameter	Sample number[a] 830 4-7"[b]	831 7-10"[b]	832 12-15"[b]	833 15-18"[b]
Al	14500	16500	15100	17200
As	10	7	7	8
Ba	178	185	158	162
Ca	3060	3500	3360	3140
Cd	0.3	0.3	0.3	0.3
Cl	<100	<100	<100	<100
Co	6	5	7	7
Cr	12	13	13	14
Cu	18	15	22	22
F	41	25	31	28
Fe	15200	15100	16100	17000
Hg	<0.02	<0.02	<0.02	<0.02
K	2400	2160	2580	2870
Mg	2670	2940	2850	3160
Mn	234	186	219	206
Mo	<1	<1	<1	<1
Na	190	182	202	173
Ni	12	11	14	14
Pb	7	10	9	8
PO_4	58	52	79	95
Sb	<0.3	<0.3	<0.3	<0.3
Se	8.1	6.7	25.2	6.3
SiO_2	4130	4020	4130	4040
SO_4	<10	240	100	230
Sr	21	23	22	22
U	1.7	1.8	1.9	1.9
V	23	26	25	27
Zn	62.4	139	60.0	122

[a]EPA method 3050; concentrations in $\mu g/g$.
[b]Depth below top of disposal cell underliner.

Table 3.21 Geochemical data for leachate from disposal cell subpile sediments, Bodo Canyon disposal site, Colorado[a]

Constituent	Borehole 615	618	620	623
Alk	39	35	43	29
Ag	<0.01	<0.01	NA	NA
Al	<0.1	<0.1	0.1	0.2
As	<0.01	<0.01	NA	NA
B	<0.1	NA	NA	NA
Ba	<0.1	NA	NA	NA
Be	<0.01	NA	NA	NA
Br	<0.1	NA	NA	NA
Ca	19.0	13.4	14.0	11.5
Cd	<0.001	NA	NA	NA
Cl	5.	3.	3.	4.
Co	<0.05	NA	NA	NA
Cr	<0.01	NA	NA	NA
Cu	<0.02	NA	NA	NA
DOC	11.0	NA	NA	NA
F	0.8	0.9	1.0	1.3
Fe	0.05	0.05	0.05	0.13
Hg	<0.0002	NA	NA	NA
K	0.5	0.4	1.5	0.6
Mg	4.95	6.84	8.03	9.84
Mn	<0.01	NA	NA	NA
Mo	<0.01	NA	NA	NA
Na	7.11	7.85	4.56	9.25
Ni	<0.04	NA	NA	NA
NO_3	<0.1	NA	NA	NA
Pb	<0.01	NA	NA	NA
pH	7.36	7.55	7.49	7.16

[a]Concentrations in mg/l, except Ra-226 and Ra-228 which are in pCi/l and pH, which is in standard units; DOC = dissolved organic carbon.

NA - not analyzed due to insufficient sample size.

Table 3.21 Geochemical data for leachate from disposal cell subpile sediments, Bodo Canyon disposal site, Colorado[a] (Concluded)

Constituent	Borehole 615	618	620	623
PO_4	<0.1			
Ra-226	0.2 ± 0.5	0.1 ± 0.4	0.1 ± 0.4	0.3 ± 0.4
Ra-228	NA	NA	NA	NA
Sb	<0.003	NA	NA	NA
Se	<0.005	NA	NA	NA
SiO_2	5.	4.	7.	10.
S_{11}	<0.005	NA	NA	NA
SO_4	23	27	21	35
Sr	0.07	0.08	0.08	0.10
TDS	116	110	110	154
Tl	<0.01	NA	NA	NA
U	0.0003	<0.0003	0.0017	0.0006
V	0.01	<0.01	NA	NA
Zn	0.015	0.026	0.013	0.025

[a]Concentrations in mg/l, except Ra-226 and Ra-228 which are in pCi/l and pH, which is in standard units; DOC = dissolved organic carbon.

NA - not analyzed due to insufficient sample size.

Table 3.22 Attenuation factors for the disposal cell subpile sediments (toe drain sample no. 1), Bodo Canyon disposal site, Colorado[a]

Species	Influent	Test 1 Effluent	Ratio EF/IN	Test 2 Effluent	Ratio EF/IN	Test 3 Effluent	Ratio EF/IN	Test 4 Effluent	Ratio EF/IN
Alk	593.000	453.000	0.764	492.000	0.8297	490.000	0.8263	493.000	0.8314
Ag	0.010	0.010	1.000	0.010	1.0000	0.010	1.0000	DL 0.01	0.0000
Al	0.100	DL 0.1	0.000	DL 0.1	0.0000	DL 0.1	0.0000	DL 0.1	0.0000
As	0.342	0.040	0.117	0.080	0.2339	0.036	0.1053	0.110	0.3216
B	0.300	0.200	0.667	0.200	0.6667	0.200	0.6667	0.200	0.6667
Ba	DL 0.1	0.200	-	DL 0.1	-	0.100	-	0.100	-
Be	DL 0.01	DL 0.01	-	DL 0.01	-	DL 0.01	-	DL 0.01	-
Br	DL 0.1	DL 0.1	-	DL 0.01	-	DL 0.1	-	0.200	-
Ca	566.000	541.000	0.956	531.000	0.9382	502.000	0.8869	495.000	0.8746
Cd	0.019	0.003	0.158	0.007	0.3684	0.004	0.2105	0.007	0.3684
Cl	70.000	73.000	1.043	69.000	0.9857	69.000	0.9857	69.000	0.9857
Co	0.160	DL 0.05	0.000	0.060	0.3750	DL 0.05	0.0000	DL 0.05	0.0000
Cr	DL 0.01	DL 0.01	-	DL 0.01	-	DL 0.01	-	DL 0.01	-
Cu	0.030	DL 0.02	0.000	DL 0.02	0.0000	DL 0.02	0.0000	0.030	1.0000
DOC	65.000	0.000	0.000	123.000	1.8923	50.000	0.7692	53.000	0.8154
F	0.700	0.800	1.143	0.700	1.0000	0.700	1.0000	0.700	1.0000
Fe	0.130	0.090	0.692	0.090	0.6923	0.090	0.6923	0.090	0.6923
Hg	DL 0.0002	DL 0.0002	-	DL 0.0002	-	DL 0.0002	-	DL 0.0002	-
K	17.800	7.600	0.427	12.700	0.7135	14.300	0.8034	11.500	0.6461
Mg	61.800	94.700	1.532	100.000	1.6181	109.000	1.7638	112.000	1.8123
Mn	4.460	0.340	0.076	2.660	0.5964	2.460	0.5516	2.350	0.5269
Mo	1.690	1.580	0.935	1.620	0.9586	1.620	0.9586	1.570	0.9290
Na	238.000	234.000	0.983	245.000	1.0294	236.000	0.9916	235.000	0.9874
Ni	0.060	DL 0.04	0.000	DL 0.04	0.0000	DL 0.04	0.0000	DL 0.04	0.0000
NO3	DL 0.1	DL 0.1	-	DL 0.1	-	DL 0.1	-	DL 0.1	-
Pb	DL 0.01	DL 0.01	-	DL 0.01	-	DL 0.01	-	DL 0.01	-
pH	7.650	7.820	1.022	7.270	0.9503	7.390	0.9660	7.170	0.9373
PO4	3.300	0.900	0.273	1.200	0.3636	0.600	0.1818	2.000	0.6061
Ra-226*	14.000	0.500	0.036	0.800	0.0571	0.700	0.0500	0.700	0.0500
Ra-228*	1.000	1.600	1.600	2.500	2.5000	3.700	3.7000	3.400	3.4000
Sb	DL 0.003	DL 0.003	-	0.006	-	DL 0.003	-	0.005	-
Se	0.093	0.065	0.699	0.074	0.7957	0.035	0.3763	0.041	0.4409
SiO2	51.000	32.000	0.627	46.000	0.9020	43.000	0.8431	47.000	0.9216
Sn	0.029	0.006	0.207	0.018	0.6207	0.012	0.4138	0.012	0.4138

[a]Concentrations in mg/l for influents and effluents or pCi/l* as noted.
EF - Effluent
DL - Detection limits
DOC - Dissolved Organic Carbon
TDS - Total Dissolved Solids
Alk - Alkalinity
All other species names are chemical symbols.

Table 3.22 Attenuation factors for the disposal cell subpile sediments (toe drain sample no. 1), Bodo Canyon disposal site, Colorado (Concluded)[a]

Species	Influent	Test 1 Effluent	Ratio EF/IN	Test 2 Effluent	Ratio EF/IN	Test 3 Effluent	Ratio EF/IN	Test 4 Effluent	Ratio EF/IN
SO4	1770.000	1740.000	0.983	1730.000	0.9774	1700.000	0.9605	1750.000	0.9887
Sr	2.810	2.270	0.808	2.710	0.9644	2.510	0.8932	2.770	0.9858
TDS	3200.000	2970.000	0.928	3060.000	0.9563	3030.000	0.9469	3050.000	0.9531
Tl	DL 0.01	DL 0.01	-	DL 0.01	-	DL 0.01	-	DL 0.01	-
U	4.000	3.290	0.823	3.120	0.7800	3.080	0.7700	3.460	0.8650
V	13.600	2.110	0.155	5.940	0.4368	3.310	0.2434	6.040	0.4441
Zn	1.180	0.104	0.088	2.130	1.8051	2.2500	1.9068	0.358	0.3034

[a]Concentrations in mg/l for influents and effluents or pCi/l* as noted.
EF - Effluent
DL - Detection limits
DOC - Dissolved Organic Carbon
TDS - Total Dissolved Solids
Alk - Alkalinity
All other species names are chemical symbols.

Table 3.23 Attenuation factors for the disposal cell subpile sediments (toe drain sample no. 2), Bodo Canyon disposal site, Colorado[a]

Species		Test 1	Ratio	Test 2	Ratio	Test 3	Ratio	Test 4	Ratio
	Influent	Effluent	EF/IN	Effluent	EF/IN	Effluent	EF/IN	Effluent	EF/IN
Alk	593.00	438.000	0.722	470.000	0.792	453.000	0.764	457.000	0.771
Ag	DL 0.01	0.010	--	DL 0.01	--	DL 0.01	--	DL 0.01	--
Al	0.200	DL 0.1	0.000	DL 0.1	0.0000	DL 0.1	0.0000	DL 0.01	0.0000
As	0.269	0.080	0.297	0.033	0.1227	0.070	0.2602	0.050	0.1859
B	0.200	0.200	1.000	0.200	1.0000	0.200	1.0000	0.200	1.0000
Ba	DL 0.1	0.200	--	DL 0.1	--	0.100	--	0.100	--
Be	DL 0.01	DL 0.01	--	DL 0.01	--	DL 0.01	--	DL 0.01	--
Br	DL 0.1	DL 0.1	--	DL 0.01	--	DL 0.1	--	DL 0.1	--
Ca	583.000	539.000	0.925	487.000	0.8353	512.000	0.8782	479.000	0.8216
Cd	0.020	0.005	0.250	0.003	0.1500	0.005	0.2500	0.002	0.1000
Cl	70.000	73.000	1.043	69.000	0.9857	69.000	0.9857	69.000	0.9857
Co	0.160	DL 0.05	0.000	DL 0.05	0.0000	DL 0.05	0.0000	DL 0.05	0.0000
Cr	DL 0.01	DL 0.01	--	DL 0.01	00	DL 0.01	--	DL 0.01	--
Cu	0.030	DL 0.02	0.000	DL 0.02	0.0000	DL 0.02	0.0000	DL 0.02	0.0000
DOC	53.000	58.000	1.094	NA	0.0000	27.000	0.5094	17.000	0.3208
F	0.700	0.600	0.857	0.800	1.1429	0.600	0.8571	0.800	1.1429
Fe	0.140	0.120	0.857	0.090	0.6429	0.090	0.6429	0.130	0.9286
Hg	DL 0.0002	DL 0.0002	--	DL 0.0002	--	DL 0.0002	--	DL 0.0002	--
K	17.500	8.200	0.469	12.000	0.6857	14.800	0.8457	10.700	0.6114
Mg	60.600	87.500	1.444	104.000	1.7162	102.000	1.6832	130.000	2.1452
Mn	4.560	1.230	0.270	1.770	0.3882	2.580	0.5658	1.310	0.2873
Mo	1.820	1.620	0.890	1.620	0.8901	1.700	0.9341	1.700	0.9341
Na	225.000	231.000	1.027	230.000	1.0222	240.000	1.0667	242.000	1.0756
Ni	0.060	DL 0.04	0.000	DL 0.04	0.0000	DL 0.04	0.0000	DL 0.04	0.0000
NO3	DL 0.1	DL 0.1	--	DL 0.1	--	DL 0.1	--	DL 0.1	--
Pb	DL 0.01	DL 0.01	--	DL 0.01	--	DL 0.01	--	DL 0.01	--
pH	7.000	7.500	1.071	7.390	1.0557	7.370	1.0529	7.430	1.0614
PO4	3.300	1.400	0.424	0.600	0.1818	1.000	0.3030	1.500	0.4545
Ra-226	13.000	0.500	0.038	0.500	0.0385	0.500	0.0385	0.800	0.0615
Ra-228	1.100	NA	0.000	NA	0.0000	NA	0.0000	NA	0.0000
Sb	DL 0.003	0.004	--	DL 0.003	--	0.004	--	DL 0.003	--
Se	0.071	0.037	0.521	0.044	0.6197	0.043	0.6056	0.034	0.4789
SiO2	53.000	39.000	0.736	40.000	0.7547	46.000	0.8679	46.000	0.8679

[a]Concentrations in mg/l.
EF - Effluent
DL - Detection limits
DOC - Dissolved Organic Carbon
TDS - Total Dissolved Solids
Alk - Alkalinity
NA - not available
All other species names are chemical symbols.

Table 3.23 Attenuation factors for the disposal cell subpile sediments (toe drain sample no. 2), Bodo Canyon disposal site, Colorado (Concluded)[a]

Species		Test 1	Ratio	Test 2	Ratio	Test 3	Ratio	Test 4	Ratio
	Influent	Effluent	EF/IN	Effluent	EF/IN	Effluent	EF/IN	Effluent	EF/IN
Sn	0.015	0.012	0.800	0.013	0.8667	0.013	0.8667	0.011	0.7333
SO4	1750.000	1690.000	0.966	1740.000	0.9943	1700.000	0.9714	1740.000	0.9943
Sr	2.680	2.330	0.869	2.420	0.9030	2.570	0.9590	2.760	1.0299
Tl	DL 0.01	DL 0.01	--	DL 0.01	--	DL 0.01	--	DL 0.01	--
U	3.600	3.170	0.881	3.910	1.0861	3.160	0.8778	3.270	0.9083
V	13.700	4.480	0.327	2.830	0.2066	5.350	0.3905	3.070	0.2241
Zn	1.330	0.167	0.126	1.360	1.0226	1.4500	1.0902	0.205	0.1541

[a]Concentrations in mg/l.
EF - Effluent
DL - Detection limits
DOC - Dissolved Organic Carbon
TDS - Total Dissolved Solids
Alk - Alkalinity
NA - not available
All other species names are chemical symbols.

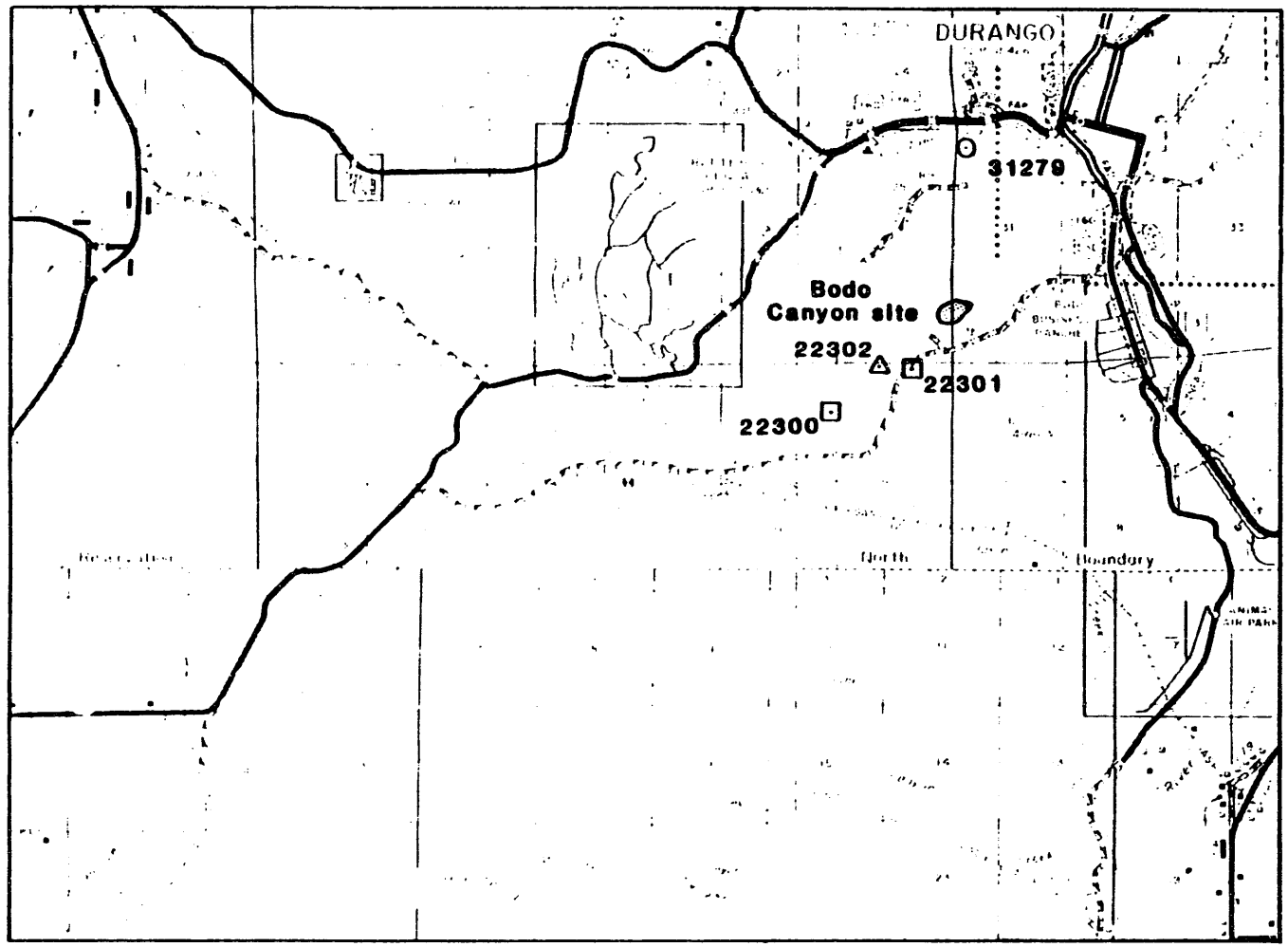
redox potential values indicated that the measured redox potential was not being controlled by any of these species. This situation is usually taken as an indication that the redox couples are not in equilibrium. Therefore, the measured Eh value was accepted as being the best indication of natural conditions and was used as the reference value in the modeling. The Eh values indicate that the groundwaters become slightly more reducing from the upgradient to the downgradient side of the disposal cell (northwest to southeast). The moderately reducing conditions in the Cliff House Formation downgradient of the disposal site have the potential to precipitate the hazardous constituents arsenic, molybdenum, selenium, and uranium. Because there are coal beds in the Menefee Formation, it is expected that reducing conditions are also present downdip in that formation.

3.2.8 Groundwater use, value, and alternative supplies

Four water wells have been identified within approximately a one-mile radius of the Bodo Canyon site (State of Colorado well permit numbers 22300, 22301, 22302, and 31279). These wells are completed in the Cliff House and Menefee Formations and are located upgradient or cross gradient of the site (Figure 3.17). Pertinent information for these wells is listed in Table 3.24. The wells are used primarily for stock-watering and domestic purposes. These wells will not be affected by the disposal cell in Bodo Canyon.

The occurrence of shallow groundwater is limited in Bodo Canyon. As discussed in Section 3.2.3, most monitor wells drilled in Bodo Canyon alluvium failed to encounter significant quantities of shallow groundwater. Based on background groundwater quality data from DOE monitor well 623, shallow groundwater in Bodo Canyon is too poor in quality for domestic use. As discussed in Section 3.2.5, concentrations or activities of molybdenum, net gross alpha, and radium-226 and -228 have exceeded MCLs at least once in this background monitor well.

Stabilization of the tailings at the Bodo Canyon site will probably not affect any currently used groundwater resources, and the use of potentially affected groundwater is unlikely. Should the potentially affected groundwater be considered for use, alternate sources of water are available. Surface water could be obtained from the Animas River. Significant quantities of deeper groundwater may be available, but at greater drilling and pumping costs.



KEY

- ⊙ Domestic well
- ⊡ Stock well
- △ Domestic & stock wells
- 46243 State of Colorado well permit numbers

0 1 2 3 Miles
Scale

FIGURE 3.17
LOCATIONS OF WATER WELLS CLOSEST TO BODO CANYON DISPOSAL SITE, COLORADO

Table 3.24 Information for water wells closest to Bodo Canyon disposal site, Colorado

State of Colorado well permit number	Yield[a] (gpm)	Drawdown (ft)	Perforated section (feet below land surface)	Water bearing unit	Use of water well	Area
22300a	1	NA	20 to 185	NA	stock	Bodo Canyon
22301	1	NA	20 to 185	NA	stock	Bodo Canyon
22302	8	0	20 to 88	Shale	stock and domestic	Bodo Canyon
31279	8	NA	32 to 101	Shale	domestic	Bodo Canyon
46214	12	NA	NA	NA	domestic	Long Hollow
46215	30	NA	50 to 540	NA	domestic	Long Hollow
46619	25	NA	NA	NA	stock	Long Hollow
106984	15	NA	NA	NA	domestic	Long Hollow

[a]gpm = gallons per minute; NA = information not available.

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DURANGO
(01, 02, 03)

PROCESSING AND DISPOSAL SITES

CALCULATIONS

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DUR-03-09-90-14-10-00	Statistical Analysis of Background Groundwater Quality in the Alluvium Statistical Analysis of Background Groundwater Quality in the Cliff House/Menefee Aquifer
DUR-03-09-90-15-01-00	Tailings Pore Water Quality: Constituents Exceeding Laboratory Method Detection Limits Constituents Exceeding MCLs or Statistical Maximum Background Concentrations
DUR-03-09-90-15-02-01	Determination of Proposed Concentration Limits at the Durango Disposal Site POC
DUR-03-09-90-14-06-00	Three Point Solution to Determine Direction of Slope and Gradient for Cliff House/Menefee Aquifer Potentiometric Surface Estimate Hydraulic Gradients in the Alluvium at Bodo Canyon Disposal Site
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DUR-03-10-90-12-05-00	Transient Seepage Rate from Disposal Cell Transient and Steady-State Seepage in 1 cm^2 During 1000 Yrs.
DUR-09-90-14-14-00(01)	Estimation of Point of Compliance Concentrations
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DUR-03-05-91-12-01-00	Determination of Alluvium Recharge Change in Response to Durango Disposal Cell Construction

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JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

OCT '90

CALCULATION COVER SHEET

CALC NO. DUR01-10-90-14-10-00 DISCIPLINE HYDRO NO. OF SHEETS 9

PROJECT: UMTRA SITE CHARACTERIZATION

SITE: DURANGO PROCESSING SITE

FEATURE: STATISTICAL ANALYSIS OF BACKGROUND GROUNDWATER QUALITY

SOURCES OF DATA:

UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:

Technical Approach Document (JEG, 1989)

"Statistical Analysis of Groundwater monitoring Data at RCRA Facilities – Interim Final Guidance (EPA, 1989).

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. ____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st prelim.	Clark Foore	10/4/90	[illegible]	[illegible]	[illegible]	10/90

B/86

2/9
cap
10/4/90
KHL
10/4/90

L.M. C... PHg

OCT '90

DURANGO CALCULATION DUR01-10-90-14-10-00

DETERMINATION OF BACKGROUND GROUNDWATER QUALITY STATISTICS, DURANGO PROCESSING SITE

PROBLEM STATEMENT

This calculation was performed to characterize background groundwater quality by defining mean, statistical maximum, and maximum observed values of constituents in the alluvium aquifer at the Durango processing site. Background water quality is defined as the quality of groundwater that would be expected at the site if processing of uranium had not occurred. Background water quality in the alluvium has been determined by chemical analysis of water samples collected from a monitor well located in an area hydraulically upgradient from the raffinate pond area. Monitor well 607 was completed at the alluvium/bedrock contact adjacent to a fault (Figure 1). Monitor well 607 monitors ground water in the vicinity of South Creek that is recharging the alluvial aquifer in the raffinate ponds area.

The background concentrations of the alluvium are used to compare with concentrations observed in the alluvium, Menefee Formation, and Point Lookout Formation downgradient of the former tailings area and raffinate ponds area to determine if groundwater in these units has been impacted by the tailings and raffinate ponds.

PROCEDURE

Background water quality was characterized by analyzing constituents listed in Table 8.1 of the Technical Approach Document (TAD) (DOE, 1989). For characterization purposes, background water quality can be characterized by describing an average concentration and a statistical maximum.

Alluvium background monitor well 607 groundwater quality data was retrieved from the UMTRA DART data management system. Once these data were retrieved, statistical operations were performed by the DART software. If the percent of nondetects for a given constituent is less than 100%, then this constituent exceeded laboratory mehtod detection limits.

ASSUMPTIONS

It is assumed that monitor well 607 samples represent background groundwater quality for the alluvium in the entire processing site area.

DATA SOURCES

All data used in this statistical analysis was obtained from the UMTRA DART data management system.

L.M. COCKS P... MB
OCT '90

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SOLUTION

The statistics of the background groundwater quality in the alluvium at the Durango processing site are included as a Table in Attachment 1. These tables list the constituent, number of samples, minimum and maximum observed, mean, median, standard deviation, percent of nondetects, statistical range (99% one sided confidence interval stat. min. and stat. max.) and the distribution type.

CONCLUSIONS

Attachment 1 lists the hazardous constituent, observed minimum, observed maximum, mean, median, standard deviation, % of nondetects, 99% confidence intervals, and the distribution type.

RESULTS

Analyses of groundwater samples indicate that NET GROSS ALPHA background maximum concentratons of cadmium, chromium, molybdenum, and selenium have exceeded the proposed EPA MCLs. However, no 99% confidence interval statistical minimums of these compounds exceed proposed EPA MCLs, EXCEPT, FOR NET GROSS ALPHA. NET GROSS ALPHA EXCEEDS EPA MCLs BY 10.5 pCi/L. No background groundwater samples were analyzed for priority pollutant organics.

IN ATTACHMENT 1 THE STATISTICAL MAXIMUM BACKGROUND CONCENTRATIONS ARE REPRESENTED BY THE 99% CONFIDENCE INTERVAL STATISTICAL MAXIMUM.

REFERENCES FOR PROCEDURES

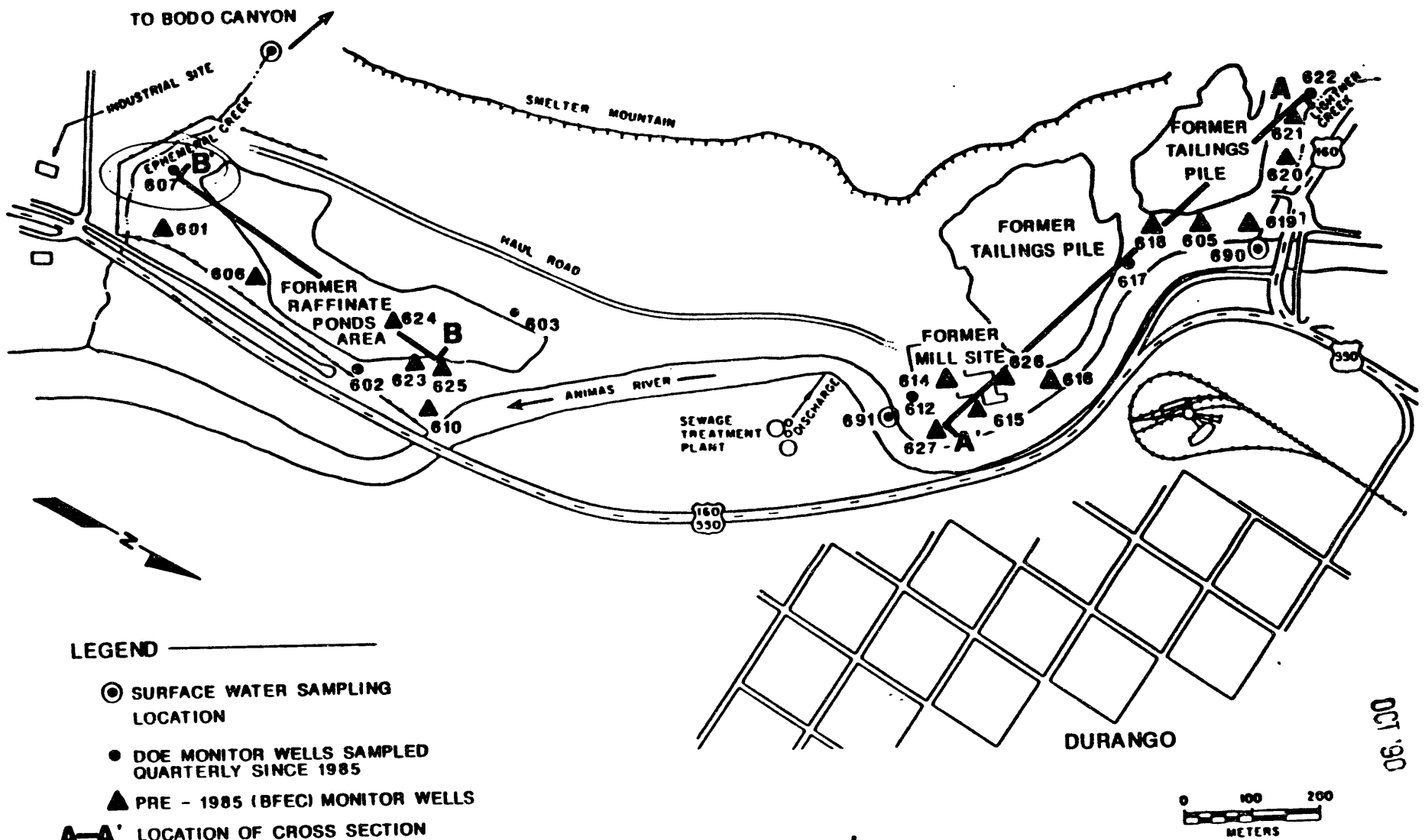
Technical Approach Document (JEG, 1989)

Hydrology Groundwater Restoration Source Document (JEG, 1990)

The procedures for calculating average and statistical maximum concentrations are discussed in "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities-Interim Final Guidance" (EPA, 1989).

ATTACHMENTS

Attachment 1 - Groundwater Quality Statistics by Parameter, Alluvium background monitor well 607



LEGEND

- SURFACE WATER SAMPLING LOCATION
- DOE MONITOR WELLS SAMPLED QUARTERLY SINCE 1985
- PRE - 1985 (BFEC) MONITOR WELLS
- A—A' LOCATION OF CROSS SECTION

FIGURE 1

MONITOR WELLS, SURFACE WATER SAMPLING LOCATIONS AND CROSS SECTION LOCATIONS DURANGO PROCESSING SITE, COLORADO

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ATTACHMENT 1

GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 607
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 07/15/90
REPORT DATE: 10/04/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
11	297.0000	506.0000	393.0000	371.2727	61.8661	0.1666	0.0	319.7149	422.8306	NORMAL	
AMMONIUM			MG/L								
3	0.0500	0.1000	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
ANTIMONY			MG/L								
4	0.0015	0.0150	0.0015	NA	NA	NA	75.0	0.0015	0.0150	NONPARAMETRIC	2,4
ARSENIC			MG/L								
11	0.0020	0.0300	0.0050	NA	NA	NA	63.6	0.0050	0.0190	NONPARAMETRIC	2
BARIUM			MG/L								
8	0.0200	0.0500	0.0500	NA	NA	NA	75.0	0.0200	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
5	0.0025	0.0050	0.0050	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,5
CADMIUM			MG/L								
11	0.0005	0.0120	0.0005	NA	NA	NA	54.5	0.0005	0.0040	NONPARAMETRIC	2
CALCIUM			MG/L								
11	147.0000	560.0000	206.0000	235.7273	116.1371	0.4927	0.0	138.9413	332.5133	NORMAL	
CHEMICAL OXYGEN DEMAND			MG/L								
1	4.0000	4.0000	4.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE			MG/L								
11	46.0000	740.0000	77.0000	106.4946	2.4819	NA	0.0	49.9262	227.1573	LOGNORMAL	7,8

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

L.M. COC... PHS
OCT '90
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 607
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 07/15/90
REPORT DATE: 10/04/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM			MG/L								
8	0.0050	0.1200	0.0050	NA	NA	NA	75.0	0.0050	0.1200	NONPARAMETRIC	2
COBALT			MG/L								
5	0.0150	0.0250	0.0250	NA	NA	NA	100.0	0.0150	0.0250	NONPARAMETRIC	2,5
COPPER			MG/L								
8	0.0050	0.0200	0.0100	NA	NA	NA	87.5	0.0050	0.0200	NONPARAMETRIC	2
CYANIDE			MG/L								
5	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,5
FLUORIDE			MG/L								
8	0.2000	0.7000	0.5000	0.4663	0.1393	0.2987	0.0	0.3186	0.6139	NORMAL	
GROSS ALPHA			PCI/L								
8	3.0000	42.0000	16.0000	17.4625	12.0853	0.6921	[illegible]	4.6527	30.2723	NORMAL	
GROSS BETA			PCI/L								
8	4.0000	40.0000	12.5000	16.7000	12.8321	0.7684	0.0	3.0986	30.3014	NORMAL	
IRON			MG/L								
11	0.0400	5.6000	0.2000	0.3020	5.7716	NA	0.0	0.0701	1.3016	LOGNORMAL	7,8
LEAD			MG/L								
8	0.0050	0.0100	0.0050	NA	NA	NA	87.5	0.0050	0.0100	NONPARAMETRIC	2
MAGNESIUM			MG/L								
11	102.0000	370.0000	156.0000	170.3636	75.8766	0.4454	0.0	107.1298	233.5975	NORMAL	

NET GROSS ALPHA = 14.5 pCi/L
STAT. MAX = 25.5 pCi/L

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Net Gross Alpha (Gross Alpha − uranium) 1 mg uranium = 686 pCi/L

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 607
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 07/15/90
REPORT DATE: 10/04/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL		DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *		
MANGANESE			MG/L								
11	0.7700	2.9800	1.7100	1.6582	0.6862	0.4138	0.0	1.0863	2.2300	NORMAL	
MERCURY			MG/L								
11	0.0001	0.0008	0.0001	NA	NA	NA	72.7	0.0001	0.0002	NONPARAMETRIC	2
MOLYBDENUM			MG/L								
11	0.0050	0.1700	0.0100	NA	NA	NA	36.4	0.0050	0.0800	NONPARAMETRIC	2
NET GROSS ALPHA **			PCI/L								
8	0.7400	33.0800	13.6750	14.1537	9.9760	0.7048	0.0	3.5796	24.7279	NORMAL	
NICKEL			MG/L								
5	0.0200	0.0500	0.0200	NA	NA	NA	80.0	0.0200	0.0500	NONPARAMETRIC	2,5
NITRATE			MG/L								
8	0.5000	6.3000	1.1500	NA	NA	NA	50.0	0.5000	6.3000	NONPARAMETRIC	2
NITRITE			MG/L								
1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRITE AND NITRATE			MG/L								
2	0.4000	0.5000	0.4500	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
POTASSIUM			MG/L								
11	4.7000	8.1000	5.7100	5.9318	1.0493	0.1769	0.0	5.0574	6.8063	NORMAL	
RADIUM-226			PCI/L								
11	0.0000	0.4000	0.2000	NA	NA	NA	18.2	0.0000	0.4000	NONPARAMETRIC	2

** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

L.M. COONS PE. PHB
OCT '90
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 607
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 07/15/90
REPORT DATE: 10/04/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-228	PCI/L	10	0.0000	2.2000	0.3000	NA	NA	NA	20.0	0.0000	1.1000	NONPARAMETRIC	2
REDOX POTENTIAL	MVOLTS	1	244.2000	244.2000	244.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	11	0.0020	0.0670	0.0240	NA	NA	NA	27.3	0.0025	0.0400	NONPARAMETRIC	2
SILVER	MG/L	11	0.0050	0.0300	0.0050	NA	NA	NA	72.7	0.0050	0.0200	NONPARAMETRIC	2
SODIUM	MG/L	11	249.0000	570.0000	332.0000	380.0909	113.2108	0.2979	0.0	285.7436	474.4382	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	11	1400.0000	4150.0000	1975.0000	2245.0000	868.7088	0.3870	0.0	1521.0378	2968.9622	NORMAL	
SULFATE	MG/L	11	923.0000	2360.0000	1540.0000	1485.7273	417.1916	0.2808	0.0	1138.0493	1833.4053	NORMAL	
SULFIDE	MG/L	5	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,5
TEMPERATURE	C - DEGREE	11	11.0000	14.2000	12.5000	12.5455	0.8311	0.0662	0.0	11.8528	13.2381	NORMAL	
THALLIUM	MG/L	5	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,5

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

L.M. COCKS P.E. PHG
OCT '90
10/4/90

ATTACHMENT 1 concluded

GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 607
SITE: DUR02 DURANGO RAFFINATE PITS
04/03/87 TO 07/15/90
REPORT DATE: 10/04/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL		DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *		
THORIUM-230			PCI/L								
3	0.0000	0.6000	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TIN			MG/L								
5	0.0025	0.0690	0.0080	NA	NA	NA	40.0	0.0025	0.0690	NONPARAMETRIC	2,5
TOTAL DISSOLVED SOLIDS			MG/L								
11	1670.0000	4910.0000	2650.0000	2827.2727	989.6473	0.3500	0.0	2002.5231	3652.0224	NORMAL	
URANIUM			MG/L								
11	0.0020	0.0130	0.0033	0.0043	0.0033	0.7812	0.0	0.0015	0.0070	NORMAL	
VANADIUM			MG/L								
5	0.0050	0.0200	0.0050	NA	NA	NA	60.0	0.0050	0.0200	NONPARAMETRIC	2,5
ZINC			MG/L								
8	0.0025	0.0320	0.0190	0.0181	0.0104	0.5739	12.5	0.0071	0.0291	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

INPUT DATA FILENAME: J:\DART\DUR02\GWQ10014.DAT

L.M. COOKS PL. PHB
OCT '90
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KKL 10/4/90

CHARACTERIZE BACKGROUND WATER QUALITY

GWQ statistics by parameter

- COMPARE WITH MCLs
- DEFINE AVERAGE
  - --SELECT MEAN OR MEDIAN DEPENDING ON DISTRIBUTION
- DEFINE STATISTICAL MAXIMUM
  - --SELECT PARAMETRIC 99% CONFIDENCE INTERVAL normal/log normal
  - --SELECT NON-PARAMETRIC 99% CONFIDENCE INTERVAL
  - --MAXIMUM OBSERVED
  - --DETECTION LIMIT

Look at % non detects if high and low sample size (less than 4 say) choose max. observed

LAB. COORD. P.E. PHB
OCT 96

10/4/90

L.M. CO. ... PE, PHR

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

OCT '90

CALCULATION COVER SHEET

CALC NO. DUR01-~~08~~ 10-90-14-11-00 DISCIPLINE HYDRO NO. OF SHEETS 16

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO PROCESSING SITE

FEATURE: (1) STATISTICAL ANALYSIS OF EXISTING GROUNDWATER CONTAMINATION AT THE ~~PROCESS~~ FORMER TAILINGS AREA
(2) STATISTICAL ANALYSIS OF EXISTING GROUNDWATER CONTAMINATION AT THE RAFFINATE PONDS AREA

SOURCES OF DATA:
UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:
UMTRA TAD, REVISED 1989

"STATISTICAL ANALYSES OF GROUND-WATER MONITORING DATA AT RCRA FACILITIES - INTERIM FINAL GUIDANCE" (EPA, 1989)

"STATISTIX - AN INTERACTIVE STATISTICAL ANALYSIS PROGRAM FOR MICROCOMPUTERS" (NH ANALYTICAL SOFTWARE)

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st prelim.	Clark Moore	10/4/90	[illegible]	[illegible]	[illegible]	10/90

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DURANGO CALCULATION DUR01-10-90-14-11-00

STATISTICAL ANALYSIS OF EXISTING GROUNDWATER CONTAMINATION

AT THE DURANGO PROCESSING SITE

PURPOSE

The purpose of this calculation is to determine if there is statistical evidence of groundwater contamination at the Durango processing site for those hazardous constituents that do not have MCLs. This calculation is divided into two parts. Part 1 addresses the analyses for the former tailings area. Part 2 addresses the analyses for the raffinate ponds area.

PART 1 - FORMER TAILINGS AREA

PROCEDURES

For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater was compared to the statistical maximum for background groundwater quality (DUR Calculation DUR01-10-9(14-10-00). If statistical maximums were unavailable for certain parameters due to less than four samples, comparisons were made with background observed maximums. The statistical maximum for background groundwater quality was exceeded for the hazardous constituents antimony, copper, nickel, thallium, vanadium, and zinc. Thallium was not observed in the background groundwater, yet exceeded laboratory detection limits in monitor well 612. Therefore thallium is possibly a groundwater contaminant related to uranium processing.

DOWN GRADIENT WELLS

The criteria of exceedence of the statistical maxium was used to determine whether antimony, copper, nickel, vanadium, and zinc should undergo further statistical analysis as they may be considered potential groundwater contaminants. Antimony could not be statistically analyzed since the number of samples was less than four in the background groundwater. When the proportion of nondetects in the downgradient sample population of a given constituent exceeded 50%, but at least 10% of the samples were quantitated, a test of proportions was used. When the proportion of nondetects in the downgradient sample population of a given constituents was less than 50%, then the analysis of variance procedure could be used. The flowchart of the procedure used in the statistical analysis is shown in Figure 1.

The test of proportions was used to statistically evaluate the difference between background and downgradient well sample analyses for the hazardous constituents copper and nickel. In order to use the test of proportions, a criteria has to be fulfilled regarding the proportion of quantitated values and the total number of samples. This criteria could not be fulfilled with the nickel sample population. Therefore nickel concentrations could not be statistically analyzed.

L.M. COONS PE. PHE

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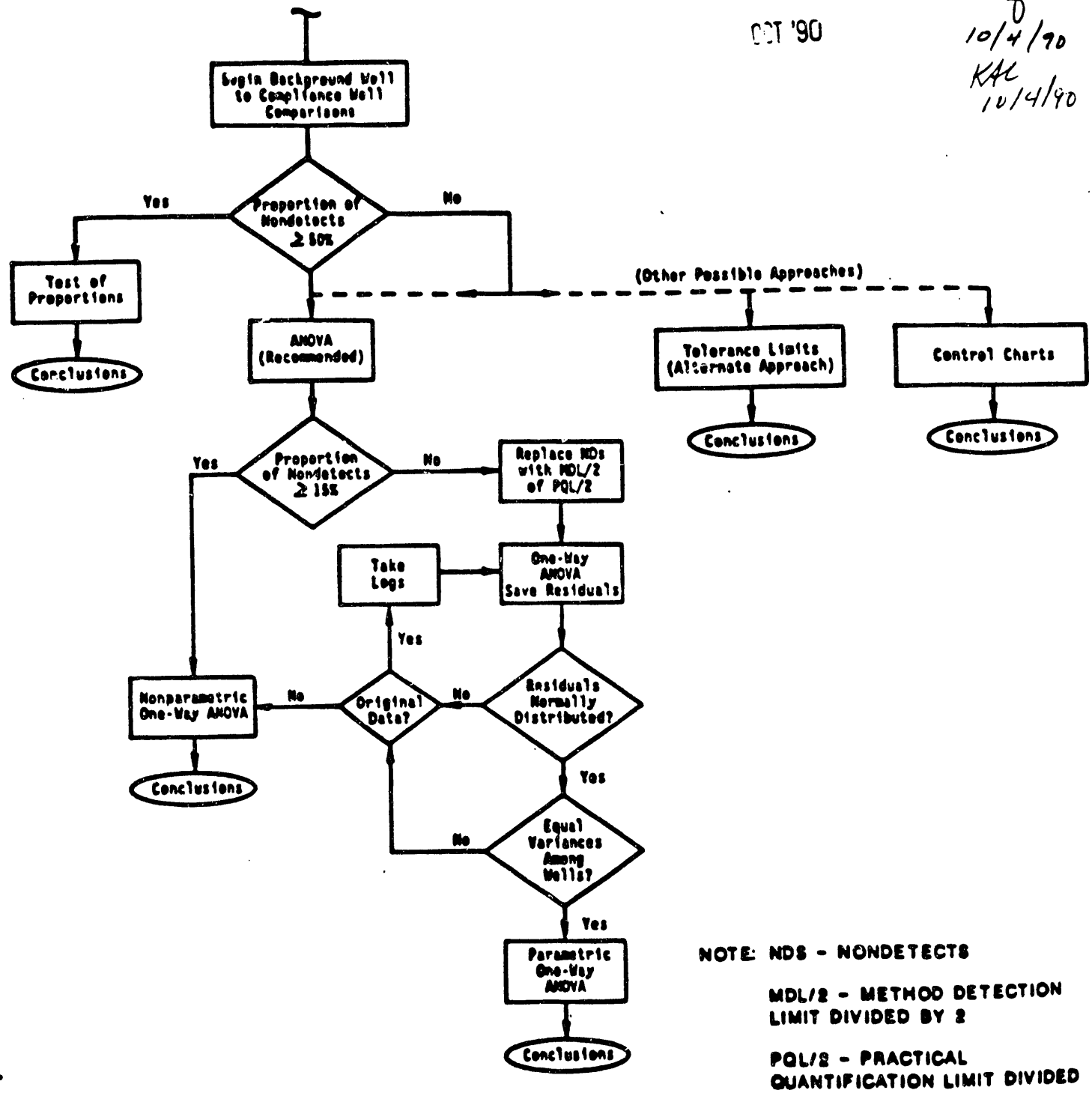

NOTE: NDS - NONDETECTS

MDL/2 - METHOD DETECTION LIMIT DIVIDED BY 2

PQL/2 - PRACTICAL QUANTIFICATION LIMIT DIVIDED BY 2

Adapted from: EPA, 1989

1

FIGURE ~~A.8~~

STATISTICAL PROCEDURE FOR ASSESSING GROUNDWATER CONTAMINATION (CONCLUDED)

OCT '90

Cap 10/4/ KAL 10/4/

The analysis of variance was used to statistically evaluate the difference between background and downgradient well sample analyses for these hazardous constituents, vanadium and zinc.

ASSUMPTIONS

For the ANOVA analysis it is assumed that the variances of the downgradient and background sample populations are not equal.

It is assumed that trends of seasonality, if any, are negligible.

DATA SOURCES

The monitor well concentration data was obtained from the UMTRA DART data management system.

SOLUTION

For the test of proportion analyses calculations were performed manually using the formula in the EPA document (EPA, 1989). These calculations are shown in Table 1.

Concentration data were entered into matrices using the statistical software package STATISTIX. The calculated results were compared to the tabulated results given in the EPA table (EPA, 1989). If the computed value exceeds the tabulated value, the monitor well concentration means of the downgradient and background populations are different. This is statistical evidence that the given constituent is a contaminant in the downgradient groundwater at the site. These input matrices and their corresponding analyses are presented in Tables 2 through 4A.

CONCLUSIONS

In the test of proportions for copper, there was no statistical significant evidence at the 5% significance level, that the downgradient wells exceed the proportion of background well samples where copper was detected. For the analysis of variance, there was a difference between the means of the background and downgradient well samples for the constituents vanadium, and zinc.

RESULTS

There is statistical evidence that the hazardous constituents vanadium and zinc are groundwater contaminants related to uranium processing in the former tailings pile area that exceed background water quality. There is evidence that thallium is a groundwater contaminant related to uranium processing. There is no statistical evidence that copper is a groundwater contaminant. Antimony and nickel could not be statistically analyzed.

REFERENCES

U.S. EPA, 1989, Statistical analysis of groundwater monitoring data at RCRA facilities.

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Table (1)

5/12 Caf

DATE 8/9/90 SUBJECT TEST OF PROPORTIONS DUR01/02 SHEET NO. 10/4/90

BY Caf CHKD. KAL 10/4/90 JOB NO.

(>50% N.D. & >10% quantitated) L.M. COONS P.E. PHG

FORMER TAILINGS AREA

COPPER DUR01

OCT '90

$x = 1$ $y = 2+2+0 = 4$ ✓

$n = 8$ $m = 8+8+8 = 24$ ✓

nP & $n(1-P) \geq 5$

$$S_D = \left[\left(\frac{1+4}{8+24}\right)\left(1 - \frac{1+4}{8+24}\right)\left(\frac{1}{8} + \frac{1}{24}\right)\right]^{1/2}$$

$$S_D = \left[(0.16)(0.84)(0.17)\right]^{1/2} = 0.15 \checkmark$$

$$Z = \left[\left(\frac{1}{8} - \frac{4}{24}\right) / 0.15\right] = 0.28 \checkmark$$

$0.28 \not\geq 1.96^a$ ✓ ∴ NO EVIDENCE OF CONTAMINATION ✓

VANADIUM [illegible] POND AREA

$x = 2$ $y = 2+1 = 3$ ✓

$n = 5$ $m = 5+1 = 6$ ✓

$nP = 5$

$$S_D = \left[(0.45)(0.55)(0.9)\right]^{1/2} = 0.47 \checkmark$$

$$Z = \left[(0.4 - 0.5)/0.47\right] = 0.21 \checkmark \not\geq 1.96^a \checkmark$$

∴ NO EVIDENCE FOR CONTAMINATION

FORM 91-005-1 (4/81)

✓a 1.96 is the 97.5th percentile from the standard normal distribution. If the absolute value of Z exceeds 1.96, this provides statistically significant evidence at the 5% significance level there is evidence of contamination.

FORM 91-005-1 (4/81)

6/16
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10/4/90

JACOBS ENGINEERING

DATE 8/7/90 SUBJECT DUR01 INPUT MATRIX FOR SX SHEET NO. 10/4/90

BY CS CHKD. KAL 10/4/90 JOB NO.

ONE-WAY NON-PARAMETRIC ANOVA T VANADIUM

MONITOR WELLS 612, 617, 607

BACKGROUND WELL

DATE	612 (DOWNGRAD.)	617 (DOWNGRAD.)	607 (UPGRADE)
4/03/89	0.60	0.05	0.02
7/15/89	0.59	M	0.005
11/16/89	0.61	0.005	0.005
5/17/90	0.31	0.005	0.02

TABLE 2

TABLE 2A

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VANADIUM FORMER TAILINGS AREA

RUSKAL-WALLIS ONEWAY NONPARAMETRIC AOV

ARIABLE	MEAN RANK	SAMPLE SIZE
ELL612	9.5	4
ELL617	4.0	3
ELL607	4.0	4
TOTAL	6.0	11

L.M. COLLINS PE, PHg

OCT '90

RUSKAL-WALLIS STATISTIC 7.3684
VALUE, USING CHI-SQUARED APPROXIMATION 0.0251

ARAMETRIC AOV APPLIED TO RANKS

OURCE	DF	SS	MS	F	P
ETWEEN	2	77.00	38.50	11.20	0.0048
ITHIN	8	27.50	3.438		
OTAL	10	104.5			

OTAL NUMBER OF VALUES WHICH WERE TIED 6
AX. DIFF. ALLOWED BETWEEN TIES 1.00E-05

ASES INCLUDED 11 MISSING CASES 1

TABULATED F VALUE = 4.46

∴ EQUAL MEANS NOT VALID,
EVIDENCE FOR CONTAMINATION

JACOBS ENGINEERING

DATE 8/7/90 BY CHKD. KM 10/4/90

SUBJECT DUR 01 INPUT MATRIX FOR SX

JOB NO. SHEET NO. 1 of 1

OCT '90

L.M. COONS INC., PHILA.

ONE-WAY NON-PARAMETRIC ANOVA - 1-IN

MONITOR WELLS 612 & 617

BACKGROUND WELL 607

DATE	612 (DOWNGRAD.)	617 (DOWNGRAD.)	607 (UPGRAD.)
4/3/89	0.068	0.01	0.069
7/15/89	0.0025	M	0.0025
11/16/89	0.045	0.034	0.034
5/12/90	0.015	0.007	0.008

D.L. = 0.005

TABLE 3

FORM 91-005-1 (4/91)

TABLE 3A

4/66
Caf
10/4/90
KAL
10/4/90

TIN FORMER TAILINGS AREA

.USKAL-WALLIS ONEWAY NONPARAMETRIC AOV

L.M. COONS PE, PHE

OCT '90

RIABLE	MEAN RANK	SAMPLE SIZE
LL612	6.6	4
LL617	5.2	3
LL607	6.0	4
OTAL	6.0	11

RUSKAL-WALLIS STATISTIC 0.3345
VALUE, USING CHI-SQUARED APPROXIMATION 0.8460

ARAMETRIC AOV APPLIED TO RANKS

OURCE	DF	SS	MS	F	P
ETWEEN	2	3.646	1.823	0.14	0.8728
ITHIN	8	105.4	13.17		
OTAL	10	109.0			

OTAL NUMBER OF VALUES WHICH WERE TIED 4
AX. DIFF. ALLOWED BETWEEN TIES 1.00E-05

ASES INCLUDED 11 MISSING CASES 1

TABULATED F = 4.46

TABULATED F > CALCULATED F

∴ EQUAL WELL MEANS VALID,

NO CONTAMINATION

10/1/6
10/4/90
10/4/90

JACOBS ENGINEERING

DATE ____ SUBJECT ____ SHEET NO. ____ JOB NO. ____

BY ____ CHKD. ____

L.M. COONS PE, PHg

OCT '90

ONE-WAY PARAMETRIC ANOVA - CINC
LOGNORMAL DISTRIBUTION
MONITOR WELLS 612, 617, 622
BACKGROUND WELL 607

DATE	612/in (DOWNGRAD.)	617/in (DOWNGRAD.)	622/in (DOWNGRAD.)	607/in (UPGRAD.)
4/5/88	2.70/.99	0.087/-2.44	0.017/-4.07	0.017/-4.07
7/1/88	2.72/1.00	0.101/-2.29	0.006/-5.12	0.015/-4.20
10/7/88	2.76/1.02	0.087/-2.44	0.005/-5.30	0.032/-3.44
4/3/89	2.40/0.88	0.082/-2.50	0.014/-4.27	0.021/-3.86
7/15/89	2.79/1.03	"	0.0025/-5.99	0.015/-4.20
11/14/89	2.82/1.04	0.188/-1.67	0.0025/-5.99	0.021/-3.86
5/12/90	0.880/-.13	0.065/-2.73	0.008/-4.83	0.006/-5.12

TABLE 4

FORM 81-008-1 (4/81)

TABLE 4A

FORMER TAILINGS AREA

11/16
Cap
10/4/90
KAL
10/4/90

L.M. COONS PE PHB

ZINC
NE WAY AOV

ARIABLE	MEAN	SAMPLE SIZE	GROUP VARIANCE
ELL612	8.329E-01	7	1.831E-01
ELL617	-2.345	6	1.298E-01
ELL622	-5.081	7	5.741E-01
ELL607	-4.107	7	2.686E-01
TOTAL	-2.687	27	

OURCE	DF	SS	MS	F	P
ETWEEN	3	141.7	47.23	159.63	0.0000
ITHIN	23	6.804	2.958E-01		
OTAL	26	148.5			

	CHI SQ	DF	P
ARTLETT'S TEST OF EQUAL VARIANCES	3.35	3	0.3403

OCHRAN'S Q 0.4968
ARGEST VAR / SMALLEST VAR 4.424

OMPONENT OF VARIANCE FOR BETWEEN GROUPS 6.962
FFECTIVE CELL SIZE 6.7

ASES INCLUDED 27 MISSING CASES 1

TABULATED F = 3.03
(APPDX B., EPA, 1989)

TABULATED F <
CALCULATED F ∴
MEANS ≠ .

EVIDENCE OF CONTAMINATION

OCT '90

U.S. EPA, 1989, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities.

PART 2 - RAFFINATE PONDS AREA

For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater is normally compared to the statistical maximum for background groundwater quality within the same geologic unit. However, there are no background monitor wells completed in bedrock units in the raffinate ponds area. Therefore, maximum observed concentrations in downgradient bedrock groundwater was compared to statistical maximums for groundwater quality within the alluvium monitored by well 607. This is a conservative approach since background concentrations in the alluvium are probably lower than concentrations in the bedrock units given the longer residence times typical for groundwater in bedrock.

PROCEDURE

If statistical maximums were unavailable for certain parameters due to less than four samples, comparisons were made with background observed maximums. The statistical maximum for background groundwater quality was exceeded for the hazardous constituents antimony, nickel, thallium, tin, and vanadium. The constituent thallium was not observed in the background groundwater, yet exceeded laboratory detection limits in monitor well 602. Therefore this hazardous constituent is possibly a groundwater contaminant related to uranium processing.

The criteria of exceedence of the statistical maximum was used to determine whether antimony, nickel, thorium-230, tin, and vanadium should undergo further statistical analysis as they may be considered potential groundwater contaminants. The constituents antimony, and thorium-230 could not be statistically analyzed since the number of samples was less than four in the background groundwater. When the proportion of nondetects in the downgradient sample population of a given constituent exceeded 50%, yet at least 10% were quantitated, a test of proportions was used. When the proportion of nondetects in the downgradient sample population of a given constituent was less than 50%, then the analysis of variance procedure could be used. The flowchart of the procedure used in the statistical analysis is shown in Figure 1.

The test of proportions was used to statistically evaluate the difference between background and downgradient well sample analyses for the hazardous constituents nickel and vanadium. In order to use the test of proportions, a criteria has to be fulfilled regarding the proportion of quantitated values and the total number of samples. This criteria could not be fulfilled with the nickel sample population. Therefore nickel concentrations could not be statistically analyzed.

L.M. COSHO P... 18
OCT '90

13/14
Cap
10/4/90
KAL
10/4/9

The analysis of variance was used to statistically evaluate the difference between background and downgradient well sample analyses for these hazardous constituent tin.

ASSUMPTIONS

For the ANOVA analysis it is assumed that the variances of the downgradient and background sample populations are not equal.

It is assumed that trends of seasonality, if any, are negligible.

DATA SOURCES

The monitor well concentration data was obtained from the UMTRA DART data management system.

SOLUTION

For the test of proportion analyses calculations were performed manually using the formula in the EPA document (EPA, 1989). These calculations are shown in Table 1.

Concentration data were entered into matrices using the statistical software package STATISTIX. The calculated results were compared to the tabulated results given n the EPA table (EPA, 1989). If the computed value exceeds the tabulated value, the monitor well concentration means of the downgradient and background populations are different. This is statistical evidence that the given constituent is a contaminant in the downgradient groundwater at the site. These input matrices and their corresponding analyses are presented in Tables 5 and 5A.

CONCLUSIONS

In the test of proportions for vanadium, there was no statistical significant evidence at the 5% significance level, that the downgradient wells exceed the proportion of background well samples where vanadium was detected. For the analysis of variance, there was no difference between the means of the background and downgradient well samples for tin, suggesting that they are the same population.

RESULTS

In summation, there is no statistical evidence that the hazardous constituents tin and vanadium are groundwater contaminants related to uranium processing in the Menefee and Point Lookout formations in former raffinate ponds area. There is evidence that thallium is a groundwater contaminant related to uranium processing. Antimony and nickel could not be statistically analyzed.

REFERENCES

U.S. EPA, 1989, Statistical Analysis of Groundwater Monitoring Data

JACOBS ENGINEERING

L.M. COONS PE, PHg

OCT '90

DATE ____ SUBJECT ____ SHEET NO. 14/1 Cof 10/4/90

BY ____ CHKD. ____ JOB NO. KAC 10/4/

ONE-WAY NON-PARAMETRIC ANOVA - TIN

MONITOR WELL 602

BACKGROUND WELL 607

DATE	602	607
1/10/89	m	m
4/03/89	0.199	0.069
7/15/89	0.0025	0.0025
11/16/89	0.138	0.034
5/12/90	0.089	0.008

TABLE 5

FORM 51-005-1 (4/81)

TABLE 5A

TIN RAFFINATE PONDS AREA

10/11
Cef
10/4/90
KAL
10/4/90

L.M. COOKS PE, PHG

OCT '90

RUSKAL-WALLIS ONEWAY NONPARAMETRIC AOV

VARIABLE	MEAN RANK	SAMPLE SIZE
ELL602	5.6	4
ELL607	3.4	4
TOTAL	4.5	8

RUSKAL-WALLIS STATISTIC 1.7078
VALUE, USING CHI-SQUARED APPROXIMATION 0.1913

ARAMETRIC AOV APPLIED TO RANKS

SOURCE	DF	SS	MS	F	P
BETWEEN	1	10.12	10.12	1.94	0.2135
WITHIN	6	31.37	5.229		
TOTAL	7	41.50			

TOTAL NUMBER OF VALUES WHICH WERE TIED 2
MAX. DIFF. ALLOWED BETWEEN TIES 1.00E-05

CASES INCLUDED 8 MISSING CASES 0

TABULATED F = 5.99
(TABLE 2, APDX. B, EPA, 1989)

TABULATED F > CALCULATED F ∴

EQUAL WELL MEANS VALID,

NO CONTAMINATION

at RCRA Facilities.

L.M. COONS PE, PHL
OCT '90

Cap
10/4/9
KAL
10/4/9

L.M. COONS PE, PHg

OCT '90

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. DUR03-09-90-14-10-00 DISCIPLINE HYDRO NO. OF SHEETS 14

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO

FEATURE: (1) STATISTICAL ANALYSIS OF BACKGROUND GROUND WATER QUALITY IN THE ALLUVIUM
(2) STATISTICAL ANALYSIS OF BACKGROUND GROUND WATER QUALITY IN THE CLIFF HOUSE/MENEFEE AQUIFER

SOURCES OF DATA:
UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:
UMTRA T.A.P., REVISED 1989

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st PRELIM.	Clark Foore	9/24/90	[illegible]	[illegible]	[illegible]	10/90
01	UPDATED GROUNDWATER						
	QUALITY DATA TABLES	Clark Foore	7/23/91				

Cap
9/24/90
KAL
10/3/90

L.M. COSINS PE, PHg

OCT '90

DURANGO CALCULATION DUR03-09-90-14-10-00

DETERMINATION OF BACKGROUND GROUNDWATER QUALITY STATISTICS, DURANGO DISPOSAL SITE

PROBLEM STATEMENT

This calculation was performed to determine the statistical maximum and maximum observed values of the background groundwater quality in two hydrogeologic units: the alluvium/weathered shale and the Cliff House/Menefee aquifer. The background concentrations of the alluvium/weathered shale are used to compare with concentrations observed in the alluvium/weathered shale downgradient of the disposal cell to determine if groundwater in this unit has been impacted by the diposal cell seepage face or retention pond discharges.

The background concentrations of the Cliff House/Menefee aquifer (the uppermost aquifer) are used to define concentration limits for hazardous constituents at the disposal site. Background groundwater quality represents groundwater which has not been affected by disposal cell construction activities. The statistical maximum is used as the proposed concentration limit for those hazardous constituents that do not have an EPA MCL. When the statistical maximum equals the laboratory method detection limit, the maximum observed background concentration is used as the proposed concentration limit. For those hazardous constituents that have an EPA MCL (including EPA secondary drinking water standards), the proposed concentration limit is chosen as the greater of the statistical maximum or the EPA MCL.

PROCEDURE

Groundwater quality data from monitor well 623 represents background groundwater quality for the alluvium/weathered shale (Figure 1). This data was retrieved from the UMTRA DART data management system. The DART software then performed statistical operations on the retrieved data.

Groundwater quality data from all monitor wells completed in the Cliff House/Menefee aquifer represent background groundwater quality for the Cliff House/Menefee aquifer (Figure 1). This data was retrieved from the UMTRA DART data mangagement system. The DART software then performed statistical operations on the retrieved data.

ASSUMPTIONS

It is assumed that monitor well 623 samples represent background groundwater quality for the alluvium/weathered shale in Bodo basin even though 623 is located in a sub-basin to Bodo basin.

It is assumed no leakage of tailings pore fluids and subsequent

3/14 Cag 9/24/91 KAL 10/3/91

migration in the Cliff House/Menefee aquifer has taken place since cell construction began in 1987.

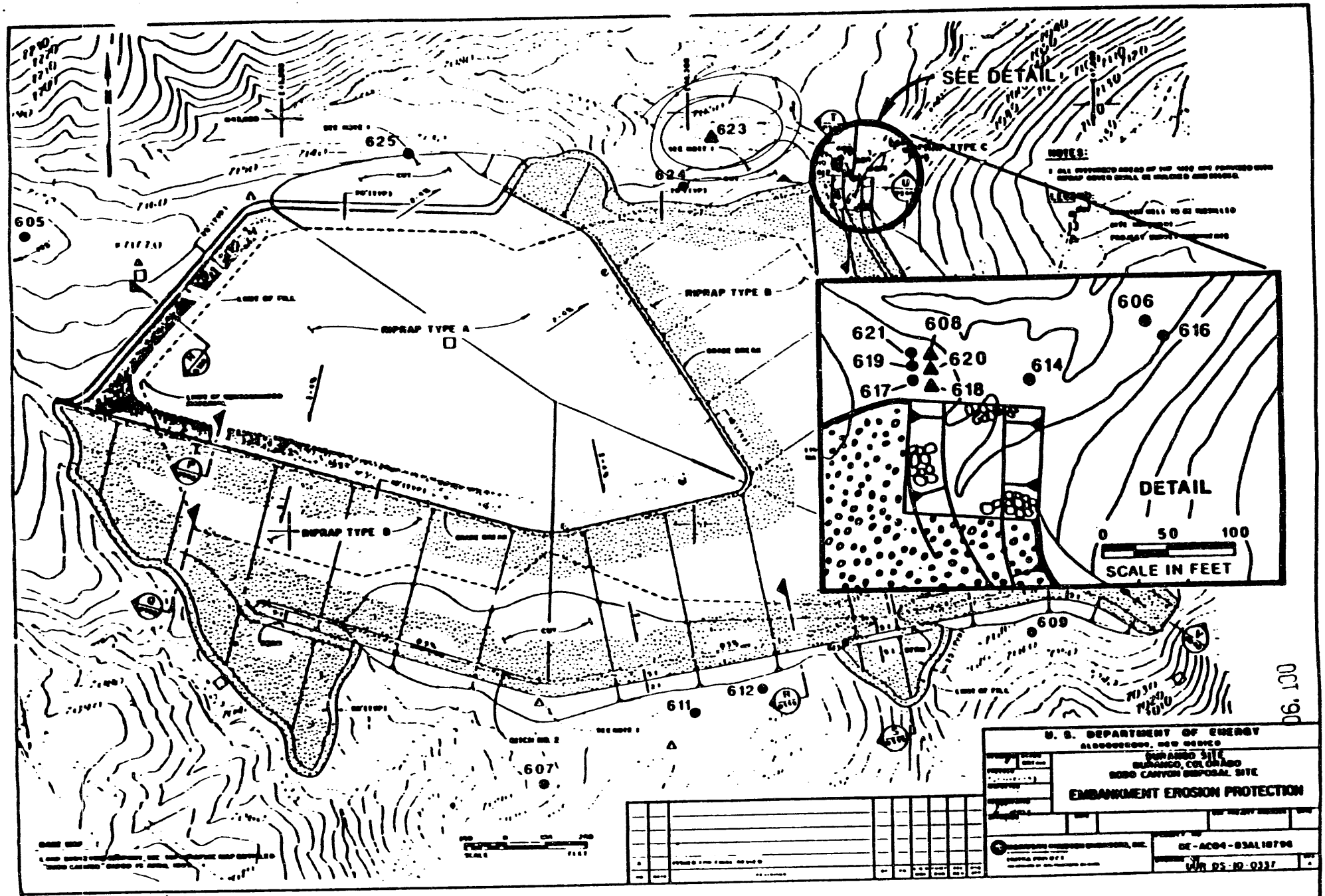
DATA SOURCES

All data used in this statistical analysis was obtained from the UMTRA DART data management system.

RESULTS

The statistics of the background groundwater quality in the alluvium/weathered shale at the Durango Disposal Site are included as a Table in Attachment 1. The statistics of the background groundwater quality in the Cliff House/Menefee aquifer at the Durango Disposal site are included as a Table in Attachment 2.

These tables list the constituent, number of samples, minimum and maximum observed, mean, median, standard deviation, percent of nondetects, statistical range (99% one sided confidence interval stat. min. and stat. max.) and the distribution type.



LEGEND

● BEDROCK MONITOR WELL

▲ ALLUVIAL MONITOR WELL

FIGURE 1

WELL LOCATIONS, BODO CANYON DISPOSAL SITE

L.M. COCKS PE, PHG

9/24/90

KAC 10/5/90

Attachment 1

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
6	441.0000	2892.0000	476.5000	645.9254	2.0968	NA	0.0	233.5881	1786.1338	LOGNORMAL	7,8
ALUMINUM			MG/L								
2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM			MG/L								
1	0.5000	0.5000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY			MG/L								
6	0.0015	0.0100	0.0015	NA	NA	NA	83.3	0.0015	0.0100	NONPARAMETRIC	2,6
ARSENIC			MG/L								
6	0.0020	0.0150	0.0050	NA	NA	NA	83.3	0.0020	0.0150	NONPARAMETRIC	2,6
BARIUM			MG/L								
6	0.0300	0.1400	0.0500	NA	NA	NA	50.0	0.0300	0.1400	NONPARAMETRIC	2,6
BERYLLIUM			MG/L								
6	0.0025	0.0050	0.0025	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,6
CADMIUM			MG/L								
6	0.0002	0.0005	0.0005	NA	NA	NA	83.3	0.0002	0.0005	NONPARAMETRIC	2,6
CALCIUM			MG/L								
6	226.0000	284.0000	249.5000	253.0000	19.7585	0.0781	0.0	225.8566	280.1434	NORMAL	
CHLORIDE			MG/L								
6	14.0000	40.5000	38.0000	34.4167	10.2099	0.2967	0.0	20.3908	48.4425	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
COBALT	MG/L	6	0.0100	0.0250	0.0250	NA	NA	NA	83.3	0.0100	0.0250	NONPARAMETRIC	2,6
COPPER	MG/L	6	0.0050	0.0100	0.0100	NA	NA	NA	83.3	0.0050	0.0100	NONPARAMETRIC	2,6
CYANIDE	MG/L	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE	MG/L	6	0.2000	0.5000	0.4500	0.4000	0.1265	0.3162	0.0	0.2262	0.5738	NORMAL	
GROSS ALPHA	PCI/L	4	0.5000	23.8000	1.5000	NA	NA	NA	50.0	0.5000	23.8000	NONPARAMETRIC	2,4
GROSS BETA	PCI/L	6	8.0000	33.8000	10.0500	15.0167	10.0921	0.6721	0.0	1.1526	28.8807	NORMAL	
IRON	MG/L	6	0.0150	0.9000	0.2600	NA	NA	NA	33.3	0.0150	0.9000	NONPARAMETRIC	2,6
LEAD	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
MAGNESIUM	MG/L	6	195.0000	227.0000	214.0000	212.8333	12.4486	0.0585	0.0	195.7321	229.9346	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE			MG/L								
6	0.3900	0.9800	0.6550	0.6400	0.2096	0.3275	0.0	0.3521	0.9279	NORMAL	
MERCURY			MG/L								
6	0.0001	0.0001	0.0001	NA	NA	NA	100.0	0.0001	0.0001	NONPARAMETRIC	2,6
MOLYBDENUM			MG/L								
6	0.0050	0.2000	0.0230	NA	NA	NA	33.3	0.0050	0.2000	NONPARAMETRIC	2,6
NET GROSS ALPHA ***			PCI/L								
4	-0.5300	22.4300	0.4700	NA	NA	NA	0.0	-0.5300	22.4300	NONPARAMETRIC	9,4
NICKEL			MG/L								
6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6
NITRATE			MG/L								
6	0.6000	2.2000	0.5000	NA	NA	NA	50.0	0.4000	2.2000	NONPARAMETRIC	2,6
NITRITE AND NITRATE			MG/L								
1	0.4700	0.4700	0.4700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
POTASSIUM			MG/L								
6	2.9000	11.0000	3.7000	4.9000	3.0874	0.6301	0.0	0.6587	9.1413	NORMAL	
RADIUM-226			PCI/L								
6	0.0500	34.9000	0.1500	NA	NA	NA	16.7	0.0500	34.9000	NONPARAMETRIC	2,6

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-226 + RADIUM-228	PCI/L	6	1.0000	35.4000	1.4750	2.6551	3.8085	NA	0.0	0.4229	16.6685	LOGNORMAL	7,8
RADIUM-228	PCI/L	6	0.5000	3.3000	1.3000	NA	NA	NA	16.7	0.5000	3.3000	NONPARAMETRIC	2,6
REDOX POTENTIAL	MVOLTS	1	185.6000	185.6000	185.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	6	0.0010	0.0150	0.0025	NA	NA	NA	100.0	0.0010	0.0150	NONPARAMETRIC	2,6
SILVER	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
SODIUM	MG/L	6	114.0000	176.0000	167.0000	159.5000	22.9151	0.1437	0.0	128.0203	190.9797	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	6	100.0000	1860.0000	1675.0000	1242.1667	762.9523	0.6142	0.0	194.0568	2290.2765	NORMAL	
STRONTIUM	MG/L	2	2.2000	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE	MG/L	6	1299.0000	1360.0000	1330.0000	1331.5000	28.0980	0.0211	0.0	1292.9002	1370.0998	NORMAL	
SULFIDE	MG/L	4	0.0500	8.0000	0.4000	NA	NA	NA	25.0	0.0500	8.0000	NONPARAMETRIC	2,4

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TEMPERATURE			C - DEGREE								
6	6.0000	9.5000	9.0000	8.0833	1.6253	0.2011	0.0	5.8505	10.3161	NORMAL	
THALLIUM			MG/L								
6	0.0005	0.0500	0.0100	NA	NA	NA	100.0	0.0005	0.0500	NONPARAMETRIC	2,6
TIN			MG/L								
6	0.0025	0.0250	0.0085	NA	NA	NA	50.0	0.0025	0.0250	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS			MG/L								
6	2240.0000	2440.0000	2340.0000	2349.6667	67.8872	0.0289	0.0	2256.4063	2442.9270	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
2	10.0000	33.0000	21.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM			MG/L								
6	0.0011	0.0020	0.0015	NA	NA	NA	50.0	0.0011	0.0020	NONPARAMETRIC	2,6
VANADIUM			MG/L								
6	0.0050	0.0200	0.0075	NA	NA	NA	50.0	0.0050	0.0200	NONPARAMETRIC	2,6
ZINC			MG/L								
6	0.0025	0.0400	0.0025	NA	NA	NA	83.3	0.0025	0.0400	NONPARAMETRIC	2,6

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

INPUT DATA FILENAME: M:\DART\DUR03\GW010023.DAT

Attachment (2.)

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND DATA FOR CLIFF HOUSE FORMATION: ALL A MONITOR WELLS
SITE: DUR03 BODO CANYON
04/03/87 TO 04/25/91
REPORT DATE: 07/23/91

CH/MF

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	55	10.0000	1449.0000	716.0000	711.0909	368.5630	0.5183	0.0	591.9174	830.2644	NORMAL	
ALUMINUM	MG/L	5	0.0500	7.5000	0.0500	NA	NA	NA	60.0	0.0500	7.5000	NONPARAMETRIC	2,5
AMMONIUM	MG/L	17	0.8000	6.2000	1.5000	2.1847	1.5264	0.6987	0.0	1.2284	3.1410	NORMAL	
ANTIMONY	MG/L	31	0.0015	0.0270	0.0015	NA	NA	NA	74.2	0.0015	0.0100	NONPARAMETRIC	2
ARSENIC	MG/L	49	0.0050	0.0240	0.0050	NA	NA	NA	83.7	0.0050	0.0050	NONPARAMETRIC	2
BARIUM	MG/L	43	0.0100	0.9000	0.0500	NA	NA	NA	72.1	0.0500	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	34	0.0025	0.0230	0.0050	NA	NA	NA	94.1	0.0050	0.0050	NONPARAMETRIC	2
CADMIUM	MG/L	49	0.0005	0.0190	0.0005	NA	NA	NA	75.5	0.0005	0.0010	NONPARAMETRIC	2
CALCIUM	MG/L	49	2.2500	505.0000	149.0000	174.4498	162.3563	0.9307	0.0	118.6224	230.2772	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	3	8.0000	52.0000	12.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND DATA FOR CLIFF HOUSE FORMATION: ALL MONITOR WELLS
SITE: DUR03 BODO CANYON
04/03/87 TO 04/25/91
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHLORIDE			MG/L								
48	8.0000	700.0000	37.0000	38.8895	2.3969	NA	0.0	28.6997	52.6972	LOGNORMAL	7,8
CHROMIUM			MG/L								
43	0.0050	0.1200	0.0050	NA	NA	NA	83.7	0.0050	0.0050	NONPARAMETRIC	2
COBALT			MG/L								
34	0.0150	0.0400	0.0250	NA	NA	NA	97.1	0.0250	0.0250	NONPARAMETRIC	2
COPPER			MG/L								
43	0.0050	0.0300	0.0100	NA	NA	NA	93.0	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE			MG/L								
24	0.0050	0.1800	0.0050	NA	NA	NA	95.8	0.0050	0.0050	NONPARAMETRIC	2
FLUORIDE			MG/L								
42	0.1000	3.7500	0.4000	0.5749	2.5676	NA	0.0	0.4042	0.8176	LOGNORMAL	7,8
GROSS ALPHA			PCI/L								
37	0.1000	38.0000	4.0000	NA	NA	NA	29.7	0.5000	14.0000	NONPARAMETRIC	2
GROSS BETA			PCI/L								
42	1.3000	62.0000	17.1500	19.9429	13.0581	0.6548	0.0	15.0648	24.8209	NORMAL	
IRON			MG/L								
49	0.0150	231.0000	0.3000	0.6128	12.1968	NA	2.0	0.2593	1.4482	LOGNORMAL	7,8
LEAD			MG/L								
43	0.0050	0.0200	0.0050	NA	NA	NA	81.4	0.0050	0.0050	NONPARAMETRIC	2

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND DATA FOR CLIFF HOUSE FORMATION: ALL MONITOR WELLS
SITE: DUR03 BODO CANYON
04/03/87 TO 04/25/91
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MAGNESIUM	MG/L	49	0.2400	458.0000	120.0000	35.6301	9.8711	NA	0.0	16.2143	78.2953	LOGNORMAL	7,8
MANGANESE	MG/L	49	0.0050	5.0000	0.0600	0.0859	7.0937	NA	12.2	0.0438	0.1686	LOGNORMAL	7,8
MERCURY	MG/L	43	0.0001	0.0004	0.0001	NA	NA	NA	90.7	0.0001	0.0001	NONPARAMETRIC	2
MOLYBDENUM	MG/L	49	0.0050	0.2200	0.0100	NA	NA	NA	49.0	0.0050	0.0500	NONPARAMETRIC	2
NET GROSS ALPHA ***	PCI/L	34	-50.1200	34.6400	2.7150	NA	NA	NA	0.0	-0.2500	12.1600	NONPARAMETRIC	9
NICKEL	MG/L	34	0.0200	0.0700	0.0200	NA	NA	NA	91.2	0.0200	0.0200	NONPARAMETRIC	2
NITRATE	MG/L	41	0.5000	10.0000	0.9000	NA	NA	NA	48.8	0.5000	1.6000	NONPARAMETRIC	2
NITRITE AND NITRATE	MG/L	14	0.1600	0.6000	0.5000	NA	NA	NA	57.1	0.4500	0.5100	NONPARAMETRIC	2
POTASSIUM	MG/L	49	4.7000	39.8000	7.3000	10.7016	8.4884	0.7932	0.0	7.7828	13.6204	NORMAL	

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND DATA FOR CLIFF HOUSE FORMATION: ALL MONITOR WELLS
SITE: DUR03 BODO CANYON
04/03/87 TO 04/25/91
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-226			PCI/L								
48	0.0500	2.0000	0.1000	NA	NA	NA	20.8	0.1000	0.1000	NONPARAMETRIC	2
RADIUM-226 + RADIUM-228			PCI/L								
46	0.2000	5.0000	0.6250	1.0424	0.9653	0.9260	0.0	0.6991	1.3857	NORMAL	
RADIUM-228			PCI/L								
46	0.1000	4.7000	0.5000	NA	NA	NA	41.3	0.5000	0.6000	NONPARAMETRIC	2
REDOX POTENTIAL			MVOLTS								
11	57.9000	768.3000	244.2000	281.7545	198.2463	0.7036	0.0	116.5406	446.9685	NORMAL	
SELENIUM			MG/L								
49	0.0010	0.0420	0.0025	NA	NA	NA	63.3	0.0025	0.0150	NONPARAMETRIC	2
SILVER			MG/L								
49	0.0050	0.0300	0.0050	NA	NA	NA	91.8	0.0050	0.0050	NONPARAMETRIC	2
SODIUM			MG/L								
49	157.0000	2040.0000	323.0000	433.7755	300.8206	0.6935	0.0	330.3362	537.2148	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
55	335.0000	5410.0000	1926.0000	2318.0727	1129.6774	0.4873	0.0	1952.7958	2683.3497	NORMAL	
STRONTIUM			MG/L								
5	0.6000	7.7000	7.2000	5.7000	2.9983	0.5260	0.0	0.6757	10.7243	NORMAL	
SULFATE			MG/L								
48	23.0000	3970.0000	882.0000	1277.0417	1161.0076	0.9091	0.0	873.5162	1680.5671	NORMAL	
SULFIDE			MG/L								
28	0.0500	42.2000	1.2500	NA	NA	NA	32.1	0.0500	5.3000	NONPARAMETRIC	2

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND DATA FOR CLIFF HOUSE FORMATION: ALL MONITOR WELLS
SITE: DUR03 BODO CANYON
04/03/87 TO 04/25/91
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TEMPERATURE	C - DEGREE	55	10.0000	20.0000	11.3000	11.4836	1.5038	0.1310	0.0	10.9974	11.9699	NORMAL	
THALLIUM	MG/L	34	0.0050	0.0150	0.0050	NA	NA	NA	97.1	0.0050	0.0050	NONPARAMETRIC	2
THORIUM-230	PCI/L	6	0.0500	0.3000	0.1250	NA	NA	NA	50.0	0.0500	0.3000	NONPARAMETRIC	2,6
TIN	MG/L	34	0.0025	0.0390	0.0025	NA	NA	NA	70.6	0.0025	0.0130	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS	MG/L	47	670.0000	8310.0000	2270.0000	2801.8298	1660.3330	0.5926	0.0	2218.1652	3385.4943	NORMAL	
URANIUM	MG/L	46	0.0003	0.0770	0.0015	NA	NA	NA	30.4	0.0012	0.0021	NONPARAMETRIC	2
VANADIUM	MG/L	34	0.0050	0.0600	0.0100	NA	NA	NA	38.2	0.0050	0.0200	NONPARAMETRIC	2
ZINC	MG/L	43	0.0025	0.1350	0.0070	NA	NA	NA	64.2	0.0025	0.0130	NONPARAMETRIC	2

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

INPUT DATA FILENAME: M:\DART\DUR03\GW010024.DAT

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. DUR-03-09-90-15-01-00 DISCIPLINE HYDRO. NO. OF SHEETS 10

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO DISPOSAL SITE

FEATURE:
(1) TAILINGS PORE WATER QUALITY: CONSTITUENTS EXCEEDING LABORATORY METHOD DETECTION LIMITS
(2) CONSTITUENTS EXCEEDING MCLs OR STATISTICAL MAXIMUM BACKGROUND CONCENTRATIONS

SOURCES OF DATA:
UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:
UMTRA TAD, REVISED 1989

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st prelim.	[signature]	10/2/90	[signature]	10/2/90	[signature]	10/90
01	Be removed from Hrs.	[signature]	7/22/91				
	Constituent list						

L.M. COONS ... 2/10 Cay 10/2/90

OCT '90

KAL 10/31

DURANGO CALCULATION DUR03-09-90-15-01-00

DETERMINATION OF HAZARDOUS CONSTITUENTS OF CONCERN IN THE TAILINGS PORE WATER

PURPOSE

The pupose of this calculation is to determine which constituents in the tailings pore water exceed laboratory method detection limits. This information will be used to determine which constituents are hazardous constituents of concern related to uranium processing activities at the Durango Processing site.

Another purpose of this calculation is to determine which of the hazardous constituents identified as exceeding laboratory method detection limits also exceed EPA MCLs. If the constituent doesn't have EPA MCLs, it was determined if it exceeds statistical maximum background concentrations in the Cliff House/Menefee aquifer as defined in Durango calculation DUR03-09-90-14-10-00.

PROCEDURES

Tailings pore water quality data from monitor wells 200 through 204 completed in the uranium mill tailings at the Durango disposal site were retrieved from the UMTRA DART data management system. Once these data were retrieved, statistical operations were performed by the DART software.

If the percent of nondetects for a given constituent is less than 100%, then this constituent exceeded laboratory method detection limits. The statistical mean of each hazardous constituent with MCLs was then compared to the MCL. The statistical mean of each hazardous constituent without an MCL was compared to statistical maximum background concentrations in the Cliff House/Menefee aquifer as shown in Attachment 1 (see Durango calculation DUR03-09-90-14-10-00). THIS PROCEDURE IS SHOWN IN FIGURE 1.

ASSUMPTIONS

The water samples from the five monitor wells completed in the tailings are assumed to be representative of tailings pore water quality throughout all of the tailings.

DATA SOURCES

The tailings pore water quality data were obtained from the UMTRA DART data management system. The Cliff House/Menefee aquifer background groundwater quality data were obtained from the UMTRA DART data management system as well.
BACKGROUND CONCENTRATIONS IN CLIFF HOUSE/MENEFEE AQUIFER: DURANGO CALCULATION DUR03-09-90-14-10-00.

CONCLUSIONS

The statistical results of the tailings pore water quality are

FIGURE 1.

HAZARDOUS CONSTITUENTS ARE ALL LISTED CONSTITUENTS THAT EXCEED LABORATORY METHOD DETECTION LIMITS

- DART STATISTICS BY PARAMETERS FOR SOURCE MATERIALS
- IF % OF NON DETECTS = 100, NOT A HAZARDOUS CONSTITUENT
- PROVIDE A LIST THAT IS LIKELY TO BE IN OR ~~DIVDED~~ DERIVED FROM RESIDUAL RADIOACTIVE MATERIAL
  --COULD BE ANYTHING THAT EXCEEDS DETECTION FROM BATCH OR COLUMN LEACH TESTS

GWQ statistics by parameter - all background wells

Soils?

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OCT '90

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3/15 Gf 03/2/90

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enclosed as Attachment 1 of this calculation set. ~~The table in~~ Attachment 1 lists the constituent, number of samples, minimum and maximum observed concentrations, mean, median, standard deviation, percent of nondetects, statistical range, and the distribution type. A listing of which constituents in the tailings pore water which exceed laboratory method detection limits, and which constituents exceed statistical maximum background concentrations in the Cliff House/Menefee aquifer is shown in Table 1.

WHICH CONSTITUEN EXCEED EPA MCL

RESULTS

The results of this calculation are summarized in TABLE 1.

REFERENCES

The references for this procedure and the statistical analyses are listed in TABLE 2.

ATTACHMENTS

ATTACHMENT 1 : TAILINGS PORE WATER QUALITY STATISTICS

TABLE 1 RESULTS

LIST OF DESIGNATED HAZARDOUS CONSTITUENTS
DURANGO DISPOSAL SITE

TABLE 1, 40 CFR 192 CONSTITUENTS		APPENDIX I, 40 CFR 192 and 40 CFR 264 CONSTITUENTS	
EXCEEDING LMDL	MEAN OR MEDIAN EXCEEDING EPA MCL	EXCEEDING LMDL	MEAN OR MEDIAN EXCEEDING STAT. MAX. BACKGROUND
✓ARSENIC	✓ARSENIC		~~✓BERYLLIUM~~ Cap 7/22/91
✓BARIUM	✓CADMIUM	✓BERYLLIUM	✓COBALT
✓CADMIUM	✓MOLYBDENUM	✓COBALT	✓COPPER
✓CHROMIUM	Combined 1 RADIUM 226/228	✓COPPER	✓VANADIUM
✓LEAD	✓SELENIUM	✓NICKEL	✓ZINC
✓MERCURY	✓URANIUM	✓ZINC	NICKEL
✓MOLYBDENUM		VANADIUM	
✓NITRATE		✓AMMONIUM	
✓RADIUM 226/228		✓FLUORIDE	
✓SELENIUM			
✓SILVER			
✓URANIUM			
NET GROSS ALPHA (GROSS ALPHA - URANIUM)			

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OCT '90

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KAL 10/3/90

TABLE 2

REFERENCES

WHAT ARE THE REFERENCE DOCUMENTS FOR GROUNDWATER QUALITY STATISTICS?

- TECHNICAL APPROACH DOCUMENT (JEG, 1989)
- HYDROLOGY GROUNDWATER RESTORATION SOURCE DOCUMENT (JEG, 1990)
- STATISTICAL ANALYSIS OF (DRAFT) GROUNDWATER MONITORING DATA AT RCRA FACILITIES (EPA, 1989)

OCT '90
L.M. CONTROL PHS

PURE [redacted]

WATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL		DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *		
ALKALINITY			MG/L CACO3								
15	303.0000	770.0000	590.0000	534.4000	164.6979	0.3082	0.0	422.8149	645.9851	NORMAL	
AMMONIUM			MG/L								
5	0.5000	2.2000	0.5000	1.0800	0.8136	0.7534	0.0	-0.2836	2.4436	NORMAL	
ARSENIC			MG/L								
15	0.0900	0.5700	0.1900	0.2433	0.1386	0.5697	0.0	0.1496	0.3373	NORMAL	
BARIUM			MG/L								
15	0.0200	0.0600	0.0500	NA	NA	NA	66.7	0.0300	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
15	0.0050	0.1600	0.0050	NA	NA	NA	66.7	0.0050	0.1000	NONPARAMETRIC	2
CADMIUM			MG/L								
15	0.0140	0.0630	0.0370	0.0355	0.0155	0.4374	0.0	0.0250	0.0460	NORMAL	
CALCIUM			MG/L								
15	513.0000	609.0000	583.0000	564.1333	35.8725	0.0636	0.0	539.8292	588.4375	NORMAL	
CHEMICAL OXYGEN DEMAND			MG/L								
5	12.0000	52.0000	22.0000	28.4000	15.7734	0.5554	0.0	1.9684	54.8316	NORMAL	
CHLORIDE			MG/L								
15	59.0000	210.0000	75.0000	98.5533	55.6753	0.5649	0.0	60.8325	136.2742	NORMAL	
CHROMIUM			MG/L								
15	0.0050	0.2600	0.0050	NA	NA	NA	66.7	0.0050	0.1800	NONPARAMETRIC	2
COBALT			MG/L								
5	0.0700	0.2000	0.1100	0.1280	0.0492	0.3843	0.0	0.0456	0.2104	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

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OCT '90

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KAL 10/3/90

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 99% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COPPER	MG/L	15	0.0300	0.0600	0.0400	0.0447	0.0106	0.2373	0.0	0.0375	0.0518	NORMAL	
CYANIDE	MG/L	10	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
FLUORIDE	MG/L	15	0.4000	1.6000	0.6000	0.7333	0.4012	0.5471	0.0	0.4615	1.0051	NORMAL	
GROSS ALPHA	PCI/L	15	820.0000	14200.0000	2900.0000	4288.0000	3983.8804	0.9291	0.0	1588.8658	6987.1342	NORMAL	
GROSS BETA	PCI/L	15	330.0000	4300.0000	780.0000	1340.0000	1246.8131	0.9305	0.0	495.2668	2184.7332	NORMAL	
IRON	MG/L	15	0.0900	0.6300	0.1400	0.2140	0.1722	0.8047	0.0	0.0973	0.3307	NORMAL	
LEAD	MG/L	15	0.0050	0.0200	0.0050	NA	NA	NA	53.3	0.0050	0.0200	NONPARAMETRIC	2
MAGNESIUM	MG/L	15	41.2000	166.0000	68.5000	79.2133	42.2838	0.5338	0.0	50.5655	107.8612	NORMAL	
MANGANESE	MG/L	15	3.0300	8.6300	6.0100	5.6407	1.4050	0.2491	0.0	4.6888	6.5925	NORMAL	
MERCURY	MG/L	15	0.0001	0.0004	0.0001	NA	NA	NA	66.7	0.0001	0.0003	NONPARAMETRIC	2
MOLYBDENUM	MG/L	15	0.8100	3.9800	1.7300	1.9460	1.0904	0.5603	0.0	1.2073	2.6847	NORMAL	

NET GROSS ALPHA = -795.30

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

NET GROSS ALPHA (GROSS ALPHA - URANIUM) WHERE 1 MG URANIUM = [illegible] PCI/L

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OCT '90
10/24/90
KAC 10/31

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NICKEL			MG/L								
5	0.0200	0.0700	0.0400	NA	NA	NA	40.0	0.0200	0.0700	NONPARAMETRIC	2,5
NITRATE			MG/L								
15	0.5000	22.0000	1.6000	NA	NA	NA	40.0	0.5000	4.5000	NONPARAMETRIC	2
POTASSIUM			MG/L								
15	12.6000	30.6000	17.2000	19.8467	6.4953	0.3273	0.0	15.4460	24.2473	NORMAL	
RADIUM-226			PCI/L								
15	5.9000	18.0000	9.9000	10.5067	3.3484	0.3187	0.0	8.2380	12.7753	NORMAL	
RADIUM-228			PCI/L								
15	0.0000	0.8000	0.3000	NA	NA	NA	26.7	0.0000	0.7000	NONPARAMETRIC	2
SELENIUM			MG/L								
15	0.0450	0.4080	0.1320	0.1745	0.1237	0.7091	0.0	0.0906	0.2583	NORMAL	
SILVER			MG/L								
15	0.0050	0.0700	0.0050	NA	NA	NA	53.3	0.0050	0.0400	NONPARAMETRIC	2
SODIUM			MG/L								
15	122.0000	727.0000	228.0000	371.9333	248.5048	0.6681	0.0	203.5679	540.2988	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
15	1850.0000	3800.0000	2100.0000	2576.6667	755.4248	0.2932	0.0	2064.8559	3088.4775	NORMAL	
SULFATE			MG/L								
15	1540.0000	2800.0000	1710.0000	2029.3333	482.1302	0.2376	0.0	1702.6834	2355.9832	NORMAL	

ADD

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

L.M. COGGINS PE. PMB
OCT '90
10/2/90
KAL 10/3/90

T. T.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFIDE	MG/L	5	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,5
TEMPERATURE	C - DEGREE	15	9.0000	15.0000	11.5000	11.5000	1.8127	0.1576	0.0	10.2719	12.7281	NORMAL	
THALLIUM	MG/L	15	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
TIN	MG/L	5	0.0025	0.0025	0.0025	NA	NA	NA	100.0	0.0025	0.0025	NONPARAMETRIC	2,5
TOTAL DISSOLVED SOLIDS	MG/L	15	2790.0000	5080.0000	3250.0000	3710.0000	910.0628	0.2453	0.0	3093.4198	4326.5602	NORMAL	
TOTAL ORGANIC CARBON	MG/L	5	116.0000	169.0000	125.0000	137.2000	23.7634	0.1732	0.0	97.3796	177.0206	NORMAL	
URANIUM	MG/L	15	1.4700	21.6000	4.5400	7.4120	6.8766	0.9278	0.0	2.7530	12.0710	NORMAL	
VANADIUM	MG/L	5	5.7000	14.4000	11.1000	10.4720	3.9374	0.3760	0.0	3.8741	17.0699	NORMAL	
ZINC	MG/L	15	0.1920	4.7900	2.0200	2.1270	1.5515	0.7294	0.0	1.0758	3.1782	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

INPUT DATA FILENAME: J:\DART\DUR03\GW010006.DAT

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L.M. COONS

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CALCULATION COVER SHEET

CALC NO. DUR03-09-90-15-02-~~00~~ 01 DISCIPLINE HYDRO NO. OF SHEETS ~~13~~ 5

PROJECT: UMTRA SITE CHARACTERIZATION

SITE: DURANGO DISPOSAL SITE

FEATURE: Determination of proposed concentration limits at the Durango Disposal Site P.O.C.

SOURCES OF DATA:

UMTRA DART

DUR. CALC. DUR03-09-90-15-01-00

DUR. CALC. DUR03-09-90-14-10-00

SOURCES OF FORMULAE & REFERENCES:

UMTRA TAD, REVISED 1989

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	FIRST PRELIM.	Clark Gore	9/24/90	Kim A Lambert	10/3/90		
01	Revised	Clark Gore	10/4/90	L Conn	10/90	L Conn	10/90
02	Added proposed limits	Clark Gore	1/22/91				

R/86

L.M. COOKS ... PHB

OCT '90

2/5
Cap
10/4/90
KH
10/4/

DURANGO CALCULATION DUR03-09-90-15-02-00

DETERMINATION OF PROPOSED CONCENTRATION LIMITS
AT THE DURANGO DISPOSAL SITE POINT OF COMPLIANCE

PURPOSE

The purpose of this calculation is to determine proposed concentration limits at the Durango disposal site point of compliance (POC). The determination of proposed concentration limits at the POC is one part of the groundwater protection standard for the Durango Remedial Action Selection Report.

PROCEDURES

For each hazardous constituent of concern at the Durango disposal site, the EPA MCL (or EPA secondary drinking water standard) was compared to the statistical maximum background concentration in the Cliff House/Menefee aquifer. The greater of the two numbers was chosen as the proposed concentration limit at the POC. If the statistical maximum of a given constituent equalled the laboratory method detection limit, the maximum observed background concentration was chosen as the proposed concentration limit at the POC. This procedure is shown in Figure 1.

ASSUMPTIONS

It is assumed that the characterization of tailings pore water quality and Cliff House/Menefee background groundwater quality is accurate.

DATA SOURCES

The hazardous constituents of concern at the Durango disposal site were determined in Durango calculation DUR03-09-90-15-01-00.

The statistical maximum and maximum observed concentrations of background groundwater were determined in Durango calculation DUR03-09-90-14-10-00.

SOLUTION

The resultant proposed concentration limits, maximum observed background concentrations, statistical maximum background concentrations, and type of concentration limit (MCL, stat.max., or obs.max.) are listed in Table 1.

RESULTS

Statistical maxima or EPA MCLs (including EPA Secondary drinking water standards) were used for all constituents except cadmium and chromium. Observed maxima were used for cadmium and chromium since the statistical maxima equalled the laboratory method detection

FIGURE 1.

ESTABLISH CONCENTRATION LIMITS

- FOR ALL LISTED HAZARDOUS CONSTITUENTS THAT EXCEED L.M.D.T. IN SOURCE MATERIAL
- MCLs OR STATISTICAL MAXIMUM, WHICHEVER IS GREATER
- STATISTICAL MAXIMUM FOR HAZARDOUS CONSTITUENTS WITH NO MCLs

3/5
10/4/90
10/4/90

TABLE 1

PROPOSED CONCENTRATION LIMITS
DURANGO DISPOSAL SITE

HAZARDOUS CONSTITUENT IN TAILINGS PORE WATER	PROPOSED MCL	OBSERVED MAX. BACKGROUND	STAT. MAX. BACKGROUND	PROPOSED CONCENTRATION LIMIT	/ METHOD
ARSENIC	0.05	0.024	0.01	0.05	MCL
BARIUM	1.0	0.30	0.10	1.0	MCL
CADMIUM	0.01	0.02	0.001	0.02	OBS.MAX.
CHROMIUM	0.05	0.12	0.01	0.12	OBS.MAX.
LEAD	0.05	0.02	0.01	0.05	MCL
MERCURY	0.002	0.004	0.002	0.002	MCL
MOLYBDENUM	0.1	0.22	0.08	0.10	MCL
NET GROSS ALPHA	15 pCi/L	3.4 ~~18.8~~ pCi/L	13.92 ~~11.5~~ pCi/L	15 pCi/L	MCL Cap 7/22/91
NITRATE	44.0	10.0	1.6	44.0	MCL
RADIUM 226/228	5.0 pCi/L	9.2 pCi/L	0.9 pCi/L	5.0 pCi/L	MCL
SELENIUM	0.01	0.042	0.018	0.02	STAT.MAX.
SILVER	0.05	0.03	0.01	0.05	MCL
URANIUM	0.044	0.028	0.004	0.044	MCL
BERYLLIUM	NA	0.01	0.01	0.01	STAT.MAX.
COBALT	NA	0.05	0.05	0.05	STAT.MAX.
COPPER	NA	0.03	0.02	1.0	EPA DWS
NICKEL	NA	0.07	0.02		
VANADIUM	NA	0.06	0.02	0.02	STAT.MAX.
ZINC	NA	0.116	0.016	5.0	EPA DWS

ALL CONCENTRATIONS IN MG/L, EXCEPT WHERE NOTED

EPA DWS - EPA SECONDARY DRINKING WATER STANDARD

L.M. COLLINS PLANT
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3

L.M. COONS PE, PHG
OCT '90

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10/4/90

limit.

REFERENCES

Technical Approach Document (JEG, 1989)

Hydrology Groundwater Restoration Source Document (JEG, 1990)

Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (EPA, 1989)

E.M. COONS PE. PHg

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CALCULATION COVER SHEET

CALC NO. DUR03-09-90-14-06-00 DISCIPLINE HYDRO NO. OF SHEETS 10

PROJECT: UMTRA SITE CHARACTERIZATION

SITE: DURANGO DISPOSAL SITE

FEATURE: (1) THREE POINT SOLUTION TO DETERMINE DIRECTION OF SLOPE AND GRADIENT FOR CLIFF HOUSE/MENEFEE AQUIFER POTENTIOMETRIC SURFACE
(2) ~~DETERMINE~~ ESTIMATE HYDRAULIC GRADIENTS IN THE ALLUVIUM AT BODO CAYON DISPOSAL SITE.

SOURCES OF DATA: WATER LEVEL DATA: UMTRA DART DATA MANAGEMENT SYSTEM
UMTRA BOREHOLE LOG RECORDS

SOURCES OF FORMULAE & REFERENCES:
FREEZE & CHERRY, GROUNDWATER

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st PRELIM	Mark Gore	10/8/90	Kevin Atkins	10/8/90	J Coons	10/90

OCT '90

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CP
10/2/90

KAL
10/1/90

DURANGO CALCULATION DUR03-09-90-14-06-00

CALCULATION OF HYDRAULIC GRADIENTS FOR ALLUVIUM,

AND CLIFF HOUSE/MENEFEE AQUIFER AT BODO CANYON DISPOSAL SITE

PURPOSE

The purpose of these calculations is to determine the hydraulic gradients in the alluvium at the Bodo Canyon disposal site and in the Cliff House/Menefee aquifer (uppermost aquifer) at the Bodo Canyon disposal site. This calculation is performed for the alluvium to characterize groundwater flow properties in the alluvium and Cliff House/Menefee aquifers. Furthermore, the calculated hydraulic gradient of the Cliff House/Menefee is used to determine underflow rates for the mixing and dilution calculations.

PART 1 - HYDRAULIC GRADIENT IN THE ALLUVIUM

PROCEDURE

A potentiometric map cannot be made from the existing water level data since there is not a good aerial distribution of alluvium monitor wells. The monitor wells are mainly confined to the width of the deepest areas of an alluvium-filled paleochannel feature within Bodo Canyon. Furthermore, some of the alluvium monitor wells are screened across the contact with the Cliff House/Menefee bedrock and these could not be used for alluvium hydraulic gradient calculations.

Therefore the hydraulic gradient was calculated using water level data from the only monitor well pair (601 and 604) which complied with the criteria described above. The monitor well pair has contemporaneous water level data, is located within the paleochannel, and the alignment of the two monitor wells ~~is~~ parallel the paleochannel axis which ~~is~~ also parallels groundwater flow. The locations of these two monitor wells is shown in Figure 1.

The horizontal hydraulic gradient (i) is by definition the difference in hydraulic head ($h_1 - h_2$) divided by the horizontal distance along the flow path (L). Where,

$$i = \frac{(h_1 - h_2)}{L}$$

ASSUMPTIONS

The alluvium hydraulic gradient is fairly constant throughout the length of the paleochannel in Bodo Canyon.

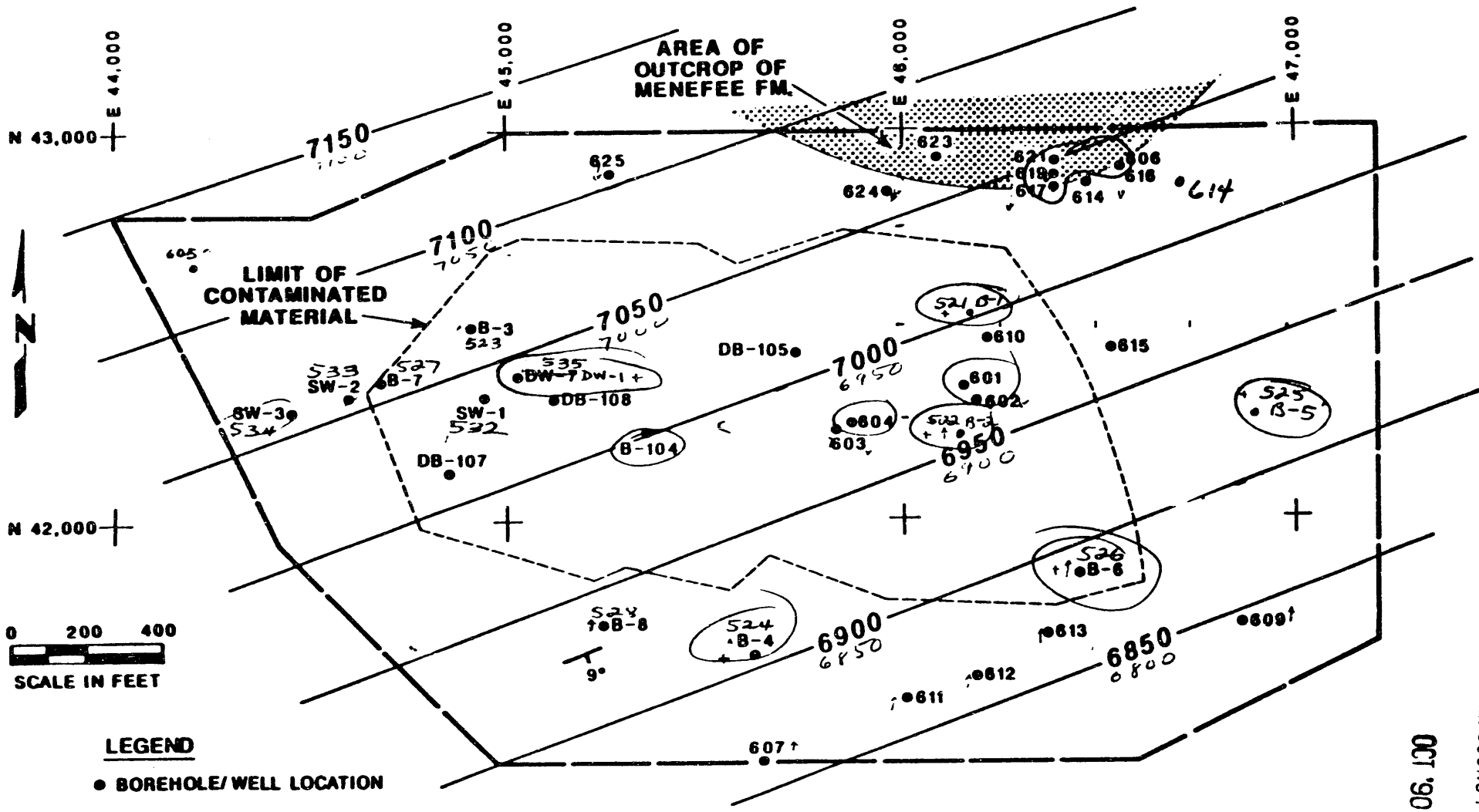

FIGURE 1
LOCATIONS OF MONITOR WELLS
601 AND 604, BODO CANYON
DISPOSAL SITE

FIGURE (1)

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W. COONS PE, PHB

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L.M. COOK...
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KAL 10/3/90

The alluvium hydraulic gradient is fairly constant even though some desaturation has taken place since 1985.

DATA SOURCES

Water level data is from the UMTRA DART data management system

SOLUTION

The difference in hydraulic head between monitor wells 601 and 604 on 16 Nov. 1985 was divided by the distance between the two monitor wells (320 feet). The data from 16 Nov. 1985 were chosen since this is the only date in the period of record that monitor well 604 had water in the well.

$$i = \frac{7020.9 - 7019.8}{320} = 0.003$$ ✓ KAL

CONCLUSIONS

The resultant hydraulic gradient from the above calculation is 0.003. This hydraulic gradient will be used to calculate the average linear groundwater velocity in the alluvium.

REFERENCES

Freeze, R.A., and Cherry, J., 1979, Groundwater (Chapter 2 page 24), Prentice Hall.

PART 2 - HYDRAULIC GRADIENT IN THE CLIFF HOUSE/MENEFEE AQUIFER

PROCEDURE

A potentiometric map cannot be made from the existing water level data since the monitor wells are screened within a number of different zones in the Cliff House/Menefee aquifer, which dips to the southeast at approximately 10 degrees.

Therefore, in order to estimate the direction of slope of the potentiometric surface (direction of groundwater flow) and the hydraulic gradient, groups of monitor wells screened in approximately the same interval (taking into account the regional dip) were identified based upon elevations and lengths of screened intervals. Table 1 shows the monitor wells selected for each group, formation of completion, elevations of the screened interval, and dates of water level measurements, and water levels used in the slope direction and gradient determination. Locations of these monitor wells are shown in Figure 2.

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DATE 10/2/90 SUBJECT TABLE 1 SHEET NO.

BY CJ CHKD. KAL 10/3/90 MONITOR WELL INFORMATION FOR THREE POINT SOLUTIONS JOB NO.

MONITOR WELL	FORMATION OF COMPLETION	INTERVAL SCREENED	WATER LEVEL	DATE OF MEASUREMENT
GROUP 1				
523	MENEFEE	7081.0-7061.0	7061.9	6/01/83
532	MENEFEE	7028.0-6997.8	7018.9	6/01/83
534	MENEFEE	7032.3-6992.2	7016.9	6/01/83
GROUP 2				
521	MENEFEE	6982.0-6967.0	6987.5	6/08/83
523	MENEFEE	7081.0-7061.0	7062.0	6/08/83
532	MENEFEE	7028.0-6997.8	7018.6	6/08/83
GROUP 3				
524	CLIFF HOUSE	7004.7-6984.7	7039.4	5/25/83
525	CLIFF HOUSE	6993.7-6973.7	7066.8	5/25/83
526	CLIFF HOUSE	6985.7-6970.7	7032.0	5/25/83

FORM 91-005-1 (4/81)

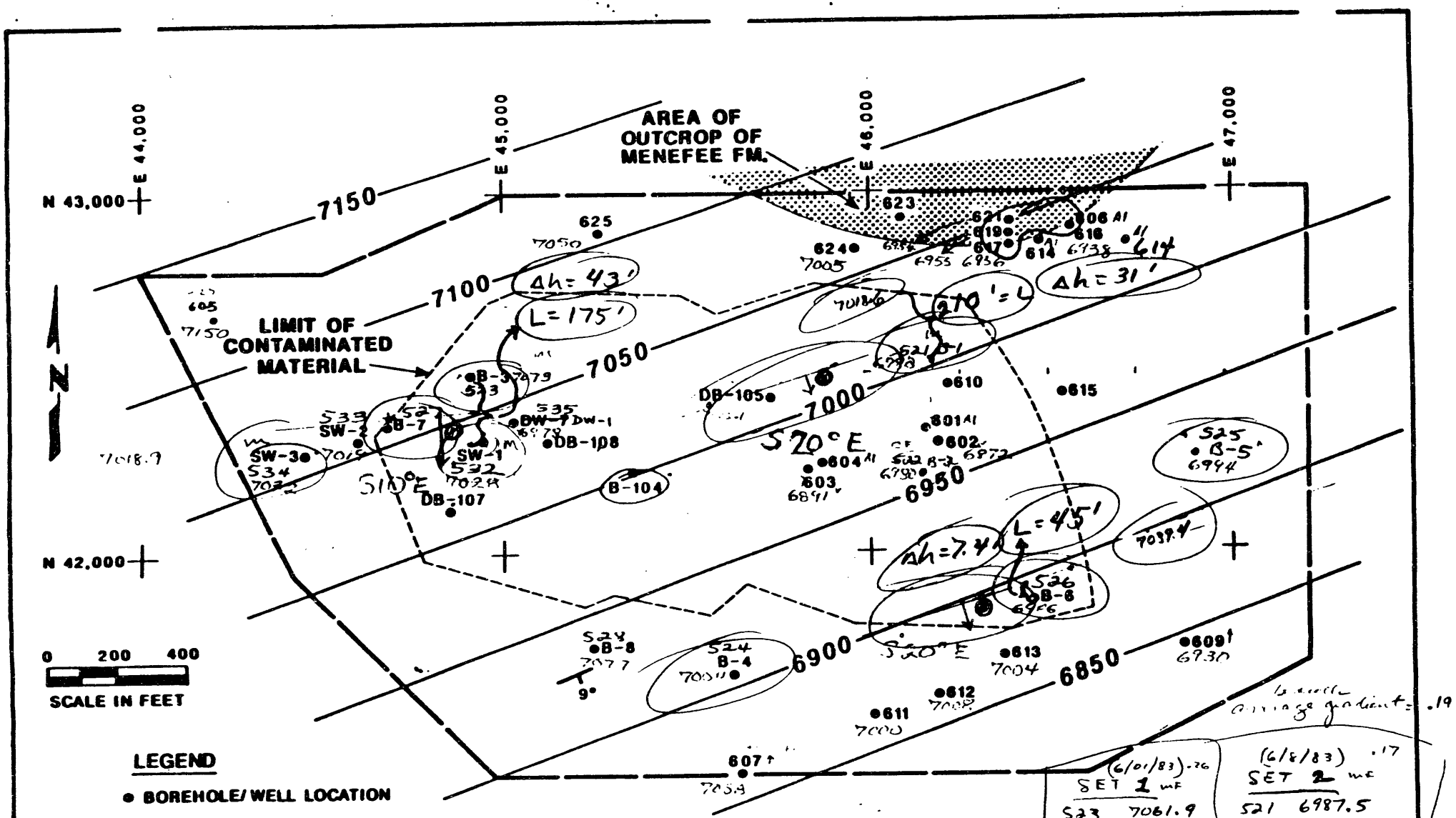

FIGURE (2)

LOCATIONS OF MONITOR WELL GROUPS AND CALCULATED DIRECTIONS

L.M. COONS PE. PHG

OCT '90

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To determine direction of slope of the potentiometric surface, a standard three-point solution for the slope of a planar surface was solved for each group of monitor wells.

ASSUMPTIONS

It is assumed that the vertical separation of screened zones within each group of monitor wells will not affect the the estimations of slope and gradient.

SOLUTION

The solution procedure is outlined as follows. For a given group of three monitor wells and water levels, the two monitor wells with the greatest difference in water levels are identified. The water level difference (in feet) is then scaled into equal units between the two well locations. The water level in the third well is identified, then the location of this same water level elevation is determined on the scale between the first two wells. A line is drawn between these two points. This is a line of equal hydraulic head. A perpendicular to this line equals the direction of slope of the potentiometric surface and flow path.

The hydraulic gradient can be estimated with the flow path line passing through one of the first two wells and through the line of equal hydraulic head. The horizontal hydraulic gradient (i) is by definition the difference in hydraulic head ($h_1 - h_2$) divided by the horizontal distance along the flow path (L). Where,

$$i = \frac{(h_1 - h_2)}{L}$$

The flow path for each group of wells was parallel to the direction of slope of the potentiometric surface. Two locations of hydraulic head along the flow path were selected for the hydraulic head difference. A schematic diagram in Figure 3 illustrates the procedure. Solutions to these three calculations are shown in Table 2. HYDRAULIC HEAD DATA WERE OBTAINED FROM THE UNITRA DART DATA MANAGEMENT SYSTEM.

CONCLUSIONS

Estimated directions of groundwater flow are to the southeast. The average hydraulic gradient from these set of monitor wells is 0.19 feet/foot. This hydraulic gradient will be used in the mixing and dilution calculation to estimate the underflow in the Cliff House/Menefee aquifer.

RESULTS

This determination of groundwater flow direction in the Cliff House/Menefee aquifer indicates that the point of compliance for the Bodo Canyon disposal site is the southeastern edge of the

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DATE 10/2/90 BY CP CHKD. KAL 10/3/90

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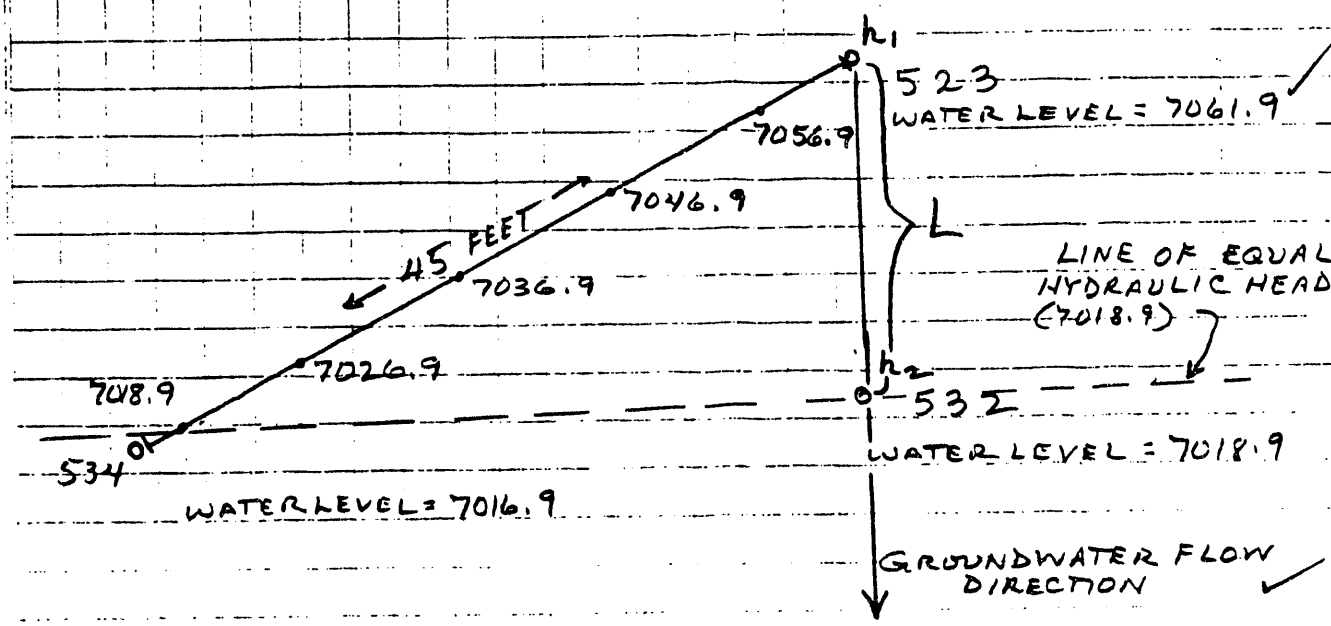
JOB NO.

SUBJECT FIGURE 3
SCHEMATIC ILLUSTRATION
GROUNDWATER FLOW DIRECTION
AND HYDRAULIC GRADIENT



Δ WATER LEVEL BETWEEN 523 AND 534 = 45 FEET

h_1 AND h_2 ALONG GROUNDWATER FLOW PATH

$$i = \frac{h_1 - h_2}{L}$$

$$i = \frac{7061.9 - 7018.9}{19}$$

$$i = 2.3 \text{ Ft/Ft}$$

EXAMPLE RESULT

FORM 91-005-1 (4/81)

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DATE 10/4/90 SUBJECT TABLE 2 SUMMARY OF SOLUTIONS SHEET NO.

BY CaP CHKD. KAL 10/4/90 JOB NO.

(G) CONCLUSIONS

GROUP	$(h_1 - h_2)$ (FEET)	L (FEET)	ESTIMATED HYDRAULIC GRADIENT	ESTIMATED DIRECTION OF HYDRULIC GRADIENT
1	(7061.9-7018.9) = 43 ✓	175	0.25 ✓	S 10° E
2	(7018.6-6987.5) = 31.1 ✓	210	0.15 ✓	S 20° E
3	(7039.4 - 7032.0) = 7.4 ✓	45	0.16 ✓	S 20° E

mean hydraulic gradient = 0.19 ✓

FORM 91-005-1 (4/81)

L.M. COONS PE. PHB
OCT '90

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KAL 10/3/90

disposal cell.

REFERENCES

Freeze, R.A., and Cherry, J., 1979, Groundwater (Chapter 2 page 24), Prentice Hall.

281	H2S AQ	.0	1.15259D-25	-24.9383	1.15318D-25	-24.9381	1.00051D+00	.0002
283	UOH +3	3.0	3.24966D-26	-25.4882	2.05117D-26	-25.6880	6.31197D-01	-.1998
284	U(OH)2 +	2.0	2.65338D-21	-20.5762	2.16264D-21	-20.6650	8.15050D-01	-.0888
285	U(OH)3 +	1.0	2.34631D-17	-16.6296	2.22937D-17	-16.6518	9.50159D-01	-.0222
286	U(OH)4 A	.0	3.69886D-14	-13.4319	3.70076D-14	-13.4317	1.00051D+00	.0002
287	U(OH)5 -	-1.0	5.31345D-12	-11.2746	5.04862D-12	-11.2968	9.50159D-01	-.0222
288	UF +3	3.0	1.49289D-29	-28.8260	9.42309D-30	-29.0258	6.31197D-01	-.1998
289	UF2 2+	2.0	5.49885D-30	-29.2597	4.48184D-30	-29.3485	8.15050D-01	-.0888
295	USO4 2+	2.0	3.71337D-30	-29.4302	3.02658D-30	-29.5190	8.15050D-01	-.0888
296	U(SO4)2	.0	1.72424D-29	-28.7634	1.72513D-29	-28.7632	1.00051D+00	.0002
301	UO2OH +1	1.0	8.09805D-15	-14.0916	7.69443D-15	-14.1138	9.50159D-01	-.0222
302	UO2)2OH2	2.0	6.01374D-24	-23.2216	4.89335D-24	-23.3104	8.15050D-01	-.0886
303	UO2)3OH5	1.0	1.95549D-29	-28.7087	1.85803D-29	-28.7309	9.50159D-01	-.0222
304	UO2CO3 A	.0	2.56192D-13	-12.5914	2.56324D-13	-12.5912	1.00051D+00	.0002
305	UO2CO3)2	-2.0	1.27574D-13	-12.8942	1.03979D-13	-12.9831	8.15050D-01	-.0888
306	UO2CO3)3	-4.0	1.12370D-15	-14.9493	4.95893D-16	-15.3046	4.41304D-01	-.3553
307	UO2F +1	1.0	3.98550D-17	-16.3995	3.78686D-17	-16.4217	9.50159D-01	-.0222
308	UO2F2 AQ	.0	2.34280D-19	-18.6303	2.34401D-19	-18.6300	1.00051D+00	.0002
309	UO2F3 -1	-1.0	6.22456D-23	-22.2059	5.91432D-23	-22.2281	9.50159D-01	-.0222
310	UO2F4 2-	-2.0	1.18279D-27	-26.9271	9.64031D-28	-27.0159	8.15050D-01	-.0886
311	UO2CL +1	1.0	3.26535D-20	-19.4861	3.10260D-20	-19.5083	9.50159D-01	-.0222
312	UO2SO4 A	.0	4.73868D-17	-16.3243	4.74112D-17	-16.3241	1.00051D+00	.0002
313	UO2SO4)2	-2.0	6.67790D-19	-18.1754	5.44283D-19	-18.2642	8.15050D-01	-.0886
353	HSO3-	-1.0	4.69037D-20	-19.3286	4.45659D-20	-19.3510	9.50159D-01	-.0222
354	H2SO3 AQ	.0	2.21929D-25	-24.6538	2.22043D-25	-24.6536	1.00051D+00	.0002

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CALCULATION COVER SHEET

CALC NO. Dur-02-89-13-~~22~~ 03-06-00 **DISCIPLINE** HYDRO **NO. OF SHEETS** 10

PROJECT: UMTRA/DOE

SITE: Durango

FEATURE: Dilution calcs for Durango Mill Tailings for both the transient state due to addition of construction water and steady-state flow through a cell

SOURCES OF DATA: DOE Drawing Number DE-AC04-83AL18796
DOE 1984a. Draft Environmental Impact Statement - Remedial Actions at Former Vanadium Corp of America Uranium Mill Site, Durango, La Plata County, DOE/EIS-0111D, UMTRA Project Office, Albuquerque, NM.
DOE Analytical results of water samples (2004-2004) from Weeks (1980)

SOURCES OF FORMULAE & REFERENCES: (HEM 1983) (Freeze and Cherry, 97)
HEM 1983 "Study and Interpretation of the Chemical Characteristics of Natural Water" USGS WSP 2254 3rd ed
Freeze R Allan, Cherry John A, 1979 "Groundwater" Prentice-Hall Inc Englewood Cliffs, New Jersey

PRELIMINARY CALC. ☒ **FINAL CALC.** ☐ **SUPERSEDES CALC. NO.** _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
	1st Preliminary	[illegible]	[illegible]	TJH	3/1/89	[illegible]	[illegible]

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JACOBS ENGINEERING

DATE 1/4/89 SUBJECT Durango Disposal Site Mixing Calcs. SHEET NO. 1

BY _____ CHKD. JJH JOB NO. _____

Statement

The purpose of these calculations are to determine the concentration of selected constituents (contained within the disposal cell at Rock Canyon) in the groundwater beneath the disposal cell.

Method and Procedures:

A simplified solute-balance equation (Henry, 1985) is used to calc. resultant concentration in groundwater beneath the cell. The equation is as follows:

$$C_F = \frac{C_1 Q_1 + C_2 Q_2}{Q_1 + Q_2}$$

Where:

C_F = final concentration
C_1 = concentration of solute in diluting water
Q_1 = volume of diluting water
C_2 = concentration of solute in leachate before dilution
Q_2 = volume of leachate

This equation is simplified because it assumes no complex chemical reactions within the saturated zone of mixing and it assumes complete mixing.

In the computations the concentrations of the leachate were based on the arithmetic average of the concentration of specific constituents found in five observation wells installed in the disposal cell (one time sampling event).

The background concentrations were the arithmetic mean of samples collected from 2 wells [illegible] the upgradient limit of the disposal cell.

FORM 91-005 1 14 81

JACOBS ENGINEERING

DATE 1/4/89 SUBJECT SHEET NO. 2

BY RWE CHKD. TJH JOB NO.

Assumptions:

The net flux through the pile will be determined by the cover materials with the lowest hydraulic conductivity. The summation of the weighted average of the flux thru the top slope and the sideslope is shown below. The relative areas of the topslope and sideslope were calculated from DOE drawing DE-AC04-83AL18796 dated 6/17/88 entitled EMBANKMENT FINAL Grading; Durango site, Bodo Canyon Disposal Site.

Area of topslope = 48.1%
Area of sideslope = 51.9%

Total area of pile = 39.6 ac
Total area of topslope ≈ 19 ac
Total area of sideslopes ≈ 20.6 ac

- Assume flux through topslope covered with Claymax™ is 1×10^{-9} cm/sec (see attached spec sheet). Additional testing was done by engineering (attached sheet)

- Assume flux thru side slope of 5×10^{-9} cm/sec based on lab testing of sodium impregnated bentonite radon barrier.

$$(.481 * 1 \times 10^{-9}\ \text{cm/sec}) + (.519 * 5 \times 10^{-9}\ \text{cm/sec}) = 3 \times 10^{-9}\ \text{cm/sec}$$

$$3 \times 10^{-9}\ \text{cm/sec} * \frac{60\ \text{sec}}{1\ \text{min}} * \frac{1\ \text{ft}}{30.48\ \text{cm}} = 6 \times 10^{-9}\ \text{ft/min}$$

$Q = KIA$ (simple Darcian flow equation) Assume vertical gradient = 1

Assume area of pile = $1.7 \times 10^6\ \text{ft}^2$

$$Q = (6 \times 10^{-9}\ \text{ft/min})(1)(1.7 \times 10^6\ \text{ft}^2) * \frac{7.48\ \text{g}}{\text{ft}^3} = .077\ \text{gpm}$$

Flux of diluting water:

Assumptions: 1) Saturated thickness of zone feeding wells is equivalent to water level in monitoring wells (MW 608) Durango

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DATE 1/4/89 SUBJECT Durango SHEET NO. 3

BY REdge CHKD. TJG JOB NO.

2.) cross-sectional area in zone of mixing equivalent to width of arroyo at northeastern edge of Bulo Canyon (≈ 400 ft)

3) Conservatism is insured by using a low water level to dilute with which would result in the highest contaminant concentrations (≈ 14 ft of saturated thickness) The static water levels are attributed to NW 6 08 and 6D6 at Bulo Canyon (see attached sheet)

4) Maximum gradient is used and taken from previous DOE document (referenced on cover sheet).

5) Simple Darcian flow calc is acceptable for conservative calc.

6) Hydraulic conductivity is taken from slug test data associated to site Monitoring wells screened in the uppermost water bearing unit. (1×10^{-4} cm/sec) Reported in DOE Draft EIS 1984a.

$Q = KIA$

where

Q = discharge in gpm

K = hydraulic conductivity (ft/min) 1×10^{-4} cm/sec

I = gradient $\left(\frac{dh}{dL}\right)$ = .042 (DOE 1984a : Table F-26)

A = cross sectional area (14' x 400') = 5600 ft²

$Q = KIA$

$Q = \left[1 \times 10^{-4} \frac{cm}{sec} * \frac{60 sec}{1 min} * \frac{1 ft}{30.48 cm}\right] * 5600 ft^2 * 7.48 \frac{gal}{ft^3} *$

$Q = .746$ gpm

FORM 91 005 1 14 81

JACOBS ENGINEERING

DATE 1/4/89 SUBJECT Durango SHEET NO. 4

BY REdge CHKD. TJG JOB NO.

Calculation: Calculate concentrations of constituents of concern after mixing has taken place below the pile.

Chemical Concentrations (mg/l)

Constituent	BG	Source	Std.
As	.0042	.15	.05
Cr	.03	.19	.05
Mo	.056	2.06	.1
Se	.003	.246	.01
U	.004	8.0	.044

$$C_F = \frac{Q_1C_1 + Q_2C_2}{Q_1 + Q_2}$$

$$\text{Arsenic} = \frac{(.35 * .0042) + (.07 * .15)}{.42}$$

$$= .031 \text{ mg/l}$$

$$\text{Chromium} = \frac{(.35 * .03) + (.07 * .19)}{.42}$$

$$= .06 \text{ mg/l}$$

$$\text{Molybdenum} = \frac{(.35 * .056) + (.07 * 2.06)}{.42}$$

$$= .42 \text{ mg/l}$$

$$\text{Selenium} = \frac{(.34 * .003) + (.07 * .246)}{.42}$$

$$= .04 \text{ mg/l}$$

$$\text{Uranium} = \frac{(.34 * .004) + (.07 * 8.0)}{.42} = 1.46 \text{ mg/l}$$

FORM 91-005 1 (4/81)

JACOBS ENGINEERING

DATE _____ SUBJECT Durango Dilution calculations SHEET NO. 5

BY REdge CHKD. TJG JOB NO. _____

Conclusions: The calculations represent the concentrations that might be expected based upon the current available data. These concentrations reflect the steady state flux through the cover. They are presented in the Table below:

Constituent	BG	Source (mg/l)	Std	Conc after mixing
As	.0042	.15	.05	.031
Cr	.03	.19	.05	.06
Mo	.056	2.06	.1	.42
Se	.003	.246	.01	.047
U	.004	8.0	.044	1.46

Based on the calculations it appears arsenic and chromium will be at or below the proposed maximum concentration limits. Molybdenum will exceed the std. by nearly 4x. Selenium will exceed the std. by nearly 4x. Uranium will exceed the standard by 30x.

The following set of calculations represent the transient flux and resultant concentrations:

FORM 91-005-1 (4/81)

JACOBS ENGINEERING

DATE 1/11/89 BY R Edge CHKD. TJU

SUBJECT Calc. conc. in subdisposal cell water (TRANSIENT CONDITIONS) Due to Construction Water

SHEET NO. 6

JOB NO.

Calc. conc. of constituents subpile (disposal cell H_2O) under the influence of construction water.

Chemical concentrations:

$Q_1 = .33$ gpm
$Q_2 = 7.2$ gpm

	B.G.*	Source*	Std.
As	.0042	.15	.05
Cr	.03	.19	.05
Mo	.056	2.06	.1
Se	.003	.246	.01
U	.004	8.0	.044

$$C_r = \frac{Q_1 C_1 + Q_2 C_2}{Q_1 + Q_2}$$

For Arsenic

$$As = \frac{(.34 * .0042) + (7.2 * .15)}{7.54}$$

$$As = .14 \text{ mg/l}$$

For Chromium

$$C_r = \frac{(.34 * .03) + (7.2 * .19)}{7.54}$$

$$C_r = .13 \text{ mg/l}$$

For Molybdenum

$$Mo = \frac{(.34 * .056) + (7.2 * 2.06)}{7.54}$$

$$Mo = 1.97 \text{ mg/l}$$

*

FORM 91-005 1 (4-81)

For Selenium

$$C_r = \frac{(.34 * .003) + (7.3 * .246)}{7.54}$$

$$C_r = .23 \text{ mg/l}$$

For Uranium

$$U = \frac{(.34 * .004) + (7.2 * 8.1)}{7.54}$$

$$U = 7.6 \text{ mg/l}$$

Assumptions:
- Net flux through the pile is 7.2 gpm. This completely overwhelms the earlier calcs in this package
- The concentrations of constituents in the disposal cell will remain constant. Since the constituents are not in equilibrium they will probably change some.
- Underflow is equal to .34 gpm - this is based on an average sat. thk. of 14ft (from MW 608) as shown in previous calcs. Bald Canyon
- This value will not be constant due to the varying K values and head over time.
- Ignores negligible influence of seep

Constituent	steady state conc	transient conc.	std
As	.026	.14	.05
Cr	.05	.13	.05
Mo	.36	[illegible]	.1
Se	.04	.23	.01
U	1.2	7.6	.044

JACOBS ENGINEERING

DATE 1/11/89 SUBJECT Durango Transient Drainage SHEET NO. 8

BY REdge CHKD. TJH JOB NO.

Conclusions: During the transient drainage time of the disposal cell which has been estimated to last 3.5-25 years (see calculation # DUR-02-89-13-01-00) The following can be said:

- Arsenic will exceed the std 2.8x
- Chromium will exceed by 3.6x
- Molybdenum will exceed by 19x
- Selenium will exceed by 23x
- Uranium will exceed by 172x

References:

Driscoll, Fletcher, 1986, Groundwater and Wells, Johnson Division, St Paul, Minn, 55112.

DOE, 1984a, Draft EIS-Remedial Action at former Vanadium Corp of America Uranium Mill Site

Freeze and Cherry, Groundwater, 1979, Prentice-Hall, Englewood Cliffs New Jersey.

FORM 91-005-1 (4/81)

SPEC DATA®

This Spec-Data sheet conforms to editorial style prescribed by The Construction Specifications Institute. The manufacturer is responsible for technical accuracy.

1. PRODUCT NAME

CLAYMAX LC™, CLAYMAX CR™ Liner System for Liquid Containment

(Formerly ENVIROMAT)

2. MANUFACTURER

Clem Environmental Corporation (CEC)

[redacted]

3. PRODUCT DESCRIPTION

Basic Use: CLAYMAX LC™ is a specially constructed, flexible, impermeable liner system which utilizes the mineral sodium bentonite clay and the geotextile polypropylene. Sodium bentonite is a high swelling smectite which gives CLAYMAX LC™ the ability to heal itself if ripped or punctured. In a hydrated (swollen) state, the clay has tremendous impermeability and a great resistance to all chemicals: acids, bases and hydrocarbons. The bentonite swells to form an impermeable barrier upon contact with fresh water.

CLAYMAX LC™ liner system can be used in construction applications for the containment or exclusion of liquid. These applications include fresh water ponds, waste lagoons, municipal landfills (including caps), tank farm containments, earthen irrigation canals, industrial containments and earthen dams. Seaming is accomplished by a simple overlap with adjoining material since the hydrated bentonite swells to form an impermeable bond. Minor damage is self-healing and major cuts or tears are easily and effectively repaired using patches of CLAYMAX LC™ material.

CLAYMAX LC™ is manufactured 13.5 feet wide and 82 feet long, rolled onto cores. This allows for easy handling at the job site. Longer material can be furnished upon request. No special installation tools or fasteners are required and CLAYMAX LC™'s flexibility speeds installation. The material can be cut with a utility knife to fit around protrusions (pipes, tanks, etc.).

CLAYMAX LC™ is designed for fast installation with a minimum of manpower, equipment and site preparation on both large and

Product Specification (Typical)—CLAYMAX LC™

Bentonite Content	1.0 lbs. per square foot Liner
Thickness	¼ inch
Liner Dimensions	13.5 feet x 82 feet
Effective Area Covered	1059.5 square feet (assume 6" overlap along one side and one end)
Roll Weight/Unit	1130 lbs. (minimum)
Permeability Coefficient	1×10^{-9} cm per second @ 35' head pressure

*Longer rolls available on special order.

Laboratory Test Data

Procedure—Six inches of sand covering CLAYMAX LC™ in a triaxial cell under thirty-five feet of water head pressure.

Group	Permeant	Permeability
Water	De-Aired Water	2×10^{-10} cm/sec.
Alkali	20% Hydrated Lime (pH 14)	6×10^{-10} cm/sec.
Acid	1% Acetic Acid (pH 1)	2×10^{-10} cm/sec.
Calcium	Calcium Chloride (10%)	2×10^{-9} cm/sec.
Alcohol	Ethyl Alcohol (10%)	2×10^{-9} cm/sec.
Petrols	Unleaded Gasoline	4×10^{-10} cm/sec.
Petrols	No. 6 Fuel Oil	3×10^{-9} cm/sec.
Petrols	10% Ethanol Gasohol	3×10^{-9} cm/sec.
Petrols	9.5% Butyl Gasohol	3×10^{-9} cm/sec.
Petrols	100% Benzine	4×10^{-10} cm/sec.

The above test performance data were produced under laboratory conditions. The actual performance characteristics may vary. No performance warranty is express or implied.

Packaging and Shipping

Roll Content	1107.0 square feet
Roll Weight	1135 lbs. (approx.) wrapped
Roll Size	14.5 feet long (PVC wrapped) x 18" diameter (approx.)

Material Specifications

Primary Backing (Typical Properties)—Polypropylene is nonbiodegradable and inert to most chemicals, acids and alkalis.

Color	Natural white
Filler Fiber	Nylon
Substrate	24 x 10 Delustered woven polypropylene, non-toxic, water permeable
Weight	4 oz. per square yard
Tensile Strength	70 lbs. per inch (minimum)
Grab Strength (ASTM D-1682)	Warp 95 lbs., Fill 70 lbs.
Mullen Burst Strength (ASTM D774)	250.25 lbs. per square inch
Puncture Strength (⅝" mandril ASTM D3787 MOD.)	349 lbs.
Melting Point	329° F
Elongation (ASTM D-1682)	Warp 15%, Fill 18%
Shrinkage	
Hot Water	Nil
Dry (20 min @ 270°F)	2%
Cover Fabric	100% spunlace polyester; open weave allows for expansion of bentonite
Weight	1 oz. per square yard
Grab Strength	Warp 30 lbs., Fill 13.6 lbs.
Burst Strength	35 lbs. per square inch
Bentonite (Sodium Montmorillonite) Sizing	Specially graded, 6 mesh and 30 mesh granules
*Mineralogical Composition	90% Montmorillonite (min.)
Adhesive	Water soluable, non-toxic
Storage	*On dry ground under roof or other protective covering

The manufacturer reserves the right to change product specifications and instructions/limitations without notice. Information contained herein supersedes previously printed material (11/87).

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DATE _____ SUBJECT CLAYMAX HYDRAULIC CONDUCTIVITY TESTS SHEET NO _____

BY B. MYERS CHKD _____ JOB NO. _____

SAMPLE CONDITIONING	0 CYCLE	3 CYCLE	10 CYCLE
NATURAL CONDITION	1.3×10^{-9} 1.0×10^{-9} 8.2×10^{-10} 9.3×10^{-10}		
WET-DRY CONDITIONING		2.5×10^{-9} 3.5×10^{-9} 2.0×10^{-9}	
FREEZE-THAW CONDITIONING		2.3×10^{-9}	
GEOMETRIC AVERAGE	1.0×10^{-9}	2.5×10^{-9}	

1 CYCLE = SOAKING 3 DAYS, THEN DRYING 2 DAYS (IN OVEN); OR
FREEZING 3 DAYS, THEN THAWING 2 DAYS

HYDRAULIC CONDUCTIVITIES ARE IN cm./sec.

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

4-60

CALC NO. DD203-09-90-14-03-02 DISCIPLINE HYDRO NO. OF SHEETS 5

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO

FEATURE:
PUMPING TEST ANALYSES

SOURCES OF DATA:
FIELD DATA COLLECTED DURING TESTS

SOURCES OF FORMULAE & REFERENCES:
Hydro Geo Chem, Inc., WHIP well Hydraulic Interpretation Program, Ver. 3.2, Tucson, Arizona

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st ISSUE	[illegible]	[illegible]	[illegible]	[illegible]	—	—
01	REVISED	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10/90
02	added term mean of all K's, estimate of vertical K	[illegible]	8/17/91	E Ted Munter	8/21/91		

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DURANGO CALCULATION DUR03-09-90-14-03-00

PUMPING TEST ANALYSES

BODO CANYON DISPOSAL SITE

PURPOSE

The purpose of these pumping tests is to estimate the transmissivity and storage coefficient of the alluvium and the underlying Cliff House/Menefee aquifer in the northeast area of the Bodo Canyon Disposal site. Drawdown and recovery measurements in monitor wells 608, 620, and 619 are evaluated. Additionaly, the geometric mean hydraulic conductivity for the alluvium and for the Cliff House/Menefee will be determined for all test data from 1983 to present. A vertical hydraulic conductivity for the alluvium will then be estimated from this data.

METHOD AND PROCEDURE

Alluvium Aquifer Test

A 44-hour pumping test was performed utilizing a four-inch well to pump from and recording subsequent drawdowns in the pumping well and two monitor wells. The distances between the pumping and monitor wells are listed below:

Monitor well	618	- 20.5 feet from 608
Pumping well	608	
Monitor well	620	- 10 feet from 608.

The pumping rate from 618 was 4 gallons per minute (gpm) for 2635 minutes. Recovery data were collected for 34 minutes after the pump was shut off.

Cliff House/Menefee Aquifer Test

A 50-minute pumping test was performed utilizing a four-inch well to pump from and recording subsequent drawdowns in the pumping well and one monitor wells. The distance between the pumping to the monitor wells are listed below:

Pumping well	617,	
Monitor well	619	- 10.6 feet from 617,

The pumping rate from 617 was 0.63 gallons per minute (gpm) for 50 minutes (the observed drawdown had stablilized). Recovery data were collected for 42 minutes after the pump was shut off.

Both Tests

A Hermit datalogger was used to automatically store the water level measurements recorded by transducers placed in the pumping well and each of five monitor wells. At the end of the aquifer

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test, data in the datalogger were transferred to an IBM-compatible personal computer.

The computer program Well Hydraulics Interpretation Program (WHIP) (Hydro Geo Chem, 1988) was used in the aquifer test analysis. WHIP uses semilog drawdown (Jacob-Cooper) analyses and an iterative parameter estimation technique with the Theis recovery analyses to obtain an analytical solution for transmissivity and storage coefficient. Theis curves are generated using these values and are graphically compared to the observed data. Individual data points can be eliminated from the analyses and the data "windowed" so that complete control over that portion of the test from which transmissivity and storage coefficient is required can be computed. No-flow and recharge boundary conditions can also be employed to obtain the best analytical solution. Hydraulic conductivity will be estimated from transmissivity and aquifer saturated thickness.

The geometric mean hydraulic conductivity for the alluvium was determined from 1989 field values in this calculation plus field and lab average values (JEG, 1985; and Dames and Moore, 1983) presented in Table 2. The vertical hydraulic conductivity for the alluvium was estimated by dividing the geometric mean horizontal hydraulic conductivity by three. The approximate 1/3 ratio for vertical to horizontal hydraulic conductivity for silt to clay material was obtained from Freeze and Cherry (1979), page 32.

The geometric mean hydraulic conductivity for the Cliff House/Menefee was determined from 1989 field values in this calculation, average field values (JEG, 1985), and field packer test values (Dames and Moore, 1983) presented in Tables 2 and 3.

ASSUMPTIONS

At the location of the aquifer test, the alluvium is unconfined. This is reasonable since the alluvium is the uppermost unit in Bodo Canyon.

At the location of the aquifer test, the Cliff House/Menefee aquifer is confined by 80 - 100 feet of clayey silt. This thickness was obtained from well logs of monitor well 619.

Using the Jacob straight-line method to analyze the data, it is assumed the flow is in the range of Darcy's law.

Water is discharged instantaneously from storage.

The aquifers are homogeneous and isotopic, has a constant thickness and a negligible slope, and is of infinite extent. The constant thickness assumption does not apply where boundary conditions were utilized for a solution.

The pumping well and all observation wells fully penetrate the aquifer and the well diameter is infinitesimal. This assumption is

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reasonable for the alluvium test since the monitor well screens extend to the bedrock contact. The monitor well used in the Cliff House/Menefee test partially penetrate the 26 feet of siltstone and coal seams that comprise the zone of the Cliff House/Menefee being tested. However, since the screen is 10 feet in length, this assumption will not adversely impact the calculation.

In order to estimate a vertical hydraulic conductivity from horizontal hydraulic conductivity data, a vertical/horizontal anisotropy ratio of 1/3 was assumed.

DATA SOURCES

Drawdown and recovery data as produced from the datalogger are included in Attachments A - D.

The pre-1989 aquifer test data was obtained from Dames and Moore (1983) and DOE (1985).

CALCULATIONS AND ANALYSIS

The data were evaluated using the program WHIP as follows. Transmissivity and storage coefficient were estimated by inputting the drawdown and recovery data files into the parameter estimation function of WHIP. The parameter estimation function utilizes the analytical homogeneous aquifer solution developed by Lai and Su (1974). The plots showing the best fit curves for the drawdown and recovery analyses are shown in the Attachments. All program input parameters for drawdown test analyses are presented in the Attachments. The plots also show analytical solutions without boundary conditions to illustrate the necessity of using boundary condition solutions. The no-flow boundary utilized in the alluvium analysis represents the edge of the paleochannel. The recharge boundary condition utilized for the analytical solution of Cliff Hous/Menefee analyes could be representative of the potentiometric surface encountering a coal seam which yield more water than the surrounding siltstone. All program input parameters for drawdown and recovery test analyses are present in the Attachments.

For the boundary condition solutions, the distance to the boundary was optimized. However, the distance to boundary was only used in solving the calculation and not used in any other Durango calculations.

RESULTS

Transmissivity and storage coefficient values from the various monitor wells for both drawdown and recovery analyses are presented in Table 1.

All aquifer test parameters are included in the WHIP printouts in Attachments A - D.

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CONCLUSIONS

Alluvium

The average transmissivity in the alluvium for the WHIP calculated drawdown and recovery data is 224 ft^2/day. At the location of this aquifer test at the time of the aquifer test, the saturated thickness was approximately 7 feet. Using the relationship of T = Kb, where:

T = Transmissivity, in ft^2/day,

K = hydraulic conductivity, in ft/day, and

b = aquifer thickness, in feet,

then the hydraulic conductivity is:

$$K = \frac{224\ ft^2/day}{7\ ft}$$

$$K = 32\ ft/day\ (0.011\ cm/sec)$$

The average storage coefficient of the alluvium for the WHIP calculated data is 0.005.

The geometric mean for all alluvium hydraulic conductivity averages in Table 2 is 0.13 ft/day. The estimated vertical hydraulic conductivity for the alluvium is 0.04 ft/day (one-third of 0.13).

Cliff House/Menefee

The average transmissivity in the Cliff House/Menefee aquifer for the WHIP calculated drawdown and recovery data is 7.5 ft^2/day. At the location of this aquifer test at the time of the aquifer test, the saturated thickness was approximately 26 feet. Using the relationship of T = Kb, where:

T = Transmissivity, in ft^2/day,

K = hydraulic conductivity, in ft/day, and

b = aquifer thickness, in feet,

then the hydraulic conductivity is:

$$K = \frac{7.5\ ft^2/day}{26\ ft}$$

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$$K = 0.3 \text{ ft/day } (1.1 \times 10^{-4} \text{ cm/sec})$$

The average storage coefficient of the alluvium for the WHIP calculated data is 0.0009.

Data from pumping well 617 could not be analyzed (see Fig. 1). The Theis method was not valid for the drawdown data.

The geometric mean of all Cliff House/Menefee hydraulic conductivities from Tables 2 and 3 is 0.07 ft/day.

REFERENCES

Lai, R.Y. and C. Su, "Non-steady flow to a large well in a leaky aquifer", Journal of Hydrology, 22, pp.333-345, 1974.

Hydro Geo Chem, 1988, WHIP Well Hydraulics Interpretation Program, Version 3.22, Tucson, Arizona.

DOE (U.S. Department of Energy), 1986. Remedial Action Plan and Site Design for Stabilization of the Inactive Mill Tailings Site at Durango, Colorado, December 1986, UMTRA-DOE/AL-050503.0000, DOE UMTRA Porject Office, Albuquerque Operations Office, Albuquerque, New Mexico.

Dames and Moore, 1983. Geotechnical Investigation for Bodo Canyon Uranium Mill Tailings Remedial Action Program, Durango Site, Durango Colorado, prepared for the U.S. Department of Energy, UMTRA Project Office, Albuquerque Operations Office, Albuquerque, New Mexico.

JACOBS ENGINEERING

L.M. COONS P.E. PHD ~~5/37~~ 6/4 Caf

OCT '90 10/5/90

DATE 10/4/90 SUBJECT TABLE 1 SHEET NO.

BY Caf CHKD. JOB NO. KAL 10/5/90

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1989 AQUIFER TEST SUMMARY

PUMPING WELL	OBSERVATION WELL	DRAWDOWN ANALYSIS T[a]	DRAWDOWN ANALYSIS S	RECOVERY T[a]	RECOVERY S
ALLUVIUM					
608	608	271	0.19	150	c
608	620	195	0.001	b	
608	618	280	0.0005[e]	b	
CLIFFHOUSE/MENEFEE					
617	619	8	0.0004	7	0.002
617	617	d	d	d	

a TRANSMISSIVITY IN FT^2/DAY

b NO RECOVERY DATA

c DIAGNOSTIC ANALYSIS DOESN'T ANALYZE FOR STORATIVITY

d DATA CANNOT BE ANALYZED

e THIS STORATIVITY IS LOW FOR AN UNCONFINED SYSTEM. ONE POSSIBLE EXPLANATION IS THAT WATER WAS RELEASED FROM A VERY THIN GRAVEL LENS WHICH IS SURROUNDED BY MATERIAL OF MUCH LOWER PERMEABILITY.

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Table 2 Hydraulic conductivities for hydrostratigraphic units, Bodo Canyon disposal site, Colorado

Hydrostratigraphic unit	Hydraulic conductivity K value (avg. of n)	Source of data[a]
Alluvium (silts and clays >20 feet deep)	0.011 ft/day (n = 8) 3.9×10^{-6} cm/s	JEG, 1985[b] (lab)
	1.32 ft/day (n = 2) 4.7×10^{-4} cm/s range = 1.19 - 1.46 ft/day	JEG, 1985[b] (field)
	0.0006 ft/day (n = 2) 2.8×10^{-7} cm/s	Dames & Moore, 1983 (lab)[c]
Weathered sandy shale (upper 15-20 feet of Cliff House)	0.11 ft/day (n = 1) 3.9×10^{-5} cm/s	JEG, 1985 (field)[b]
	1.2 ft/day (n = 11) 4.2×10^{-4} cm/s range = 0.02 - 5.7 ft/day 7.1×10^{-6} cm/s - 2.0×10^{-3} cm	Dames & Moore, 1983 (field)[c]
Sandstone layers and fracture zones (within Cliff House)	0.72 ft/day (n = 11); 2.5×10^{-4} cm/s range = 0.02 - 3.2 ft/day 7.1×10^{-6} cm/s - 1.1×10^{-3} cm/s	Dames & Moore, 1983 (field)[c]
Unweathered sandy shale (Cliff House)	0.006 ft/day (n = 2) 2.1×10^{-6} cm/s	JEG, 1985 (field)[b]
	0.056 ft/day (n = 12) 2.0×10^{-5} cm/s range = 0.0003 - 0.45 ft/day 1.1×10^{-7} cm/s - 1.6×10^{-4} cm/s	Dames & Moore, 1983 (field)[c]
Menefee Shale with coal seams	0.69 ft/day (n = 4) 2.4×10^{-4} cm/s range = 0.36 - 1.39 ft/day 1.3×10^{-4} cm/s - 4.9×10^{-4} cm/s	JEG, 1985 (field)[b]

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Hydrostratigraphic unit	Hydraulic conductivity K value (avg. of n)	Source of data[a]
Menefee Shale with coal seams	0.3 ft/day (n = 2) 1.1×10^{-4} cm/s range = 0.27 - 0.31 ft/day 9.5×10^{-5} cm/s - 1.1×10^{-4} cm/s	DOE, 1989 (field)
Alluvium	32 ft/day (n = 4) range = 21 - 40 ft/day 7.4×10^{-3} - 0.014 cm/s	DOE, 1989 (field)

[a]Field values determined from packer or slug testing of boreholes and wells represent primarily horizontal hydraulic conductivity.

[b] Reported in DOE (1986)

[c] Reported in Dames and Moore (1983)

(1983)

Table 3 Summary of Dames & Moore Packer test data for Bodo Canyon boreholes in the Cliff House AND MENEFEE FORMATIONS

Boring number	Depth of tested interval (ft)	DEPTH TO BEDROCK	Mean conductivity ft/day	Mean conductivity cm/sec	Lithology of tested interval (from boring logs)[a]
B-1 (521)	68.5 - 79.5	65'	0.11 W	3.7×10^{-5}	Sandstone layers @74.6.6 - 75.1', 78.9 - 79.5'
	79.5 - 84.5		0.19 W	6.6×10^{-5}	No sandstone or fractures noted
B-2 (522)	62.5 - 73.5	56'	0.09 W	3.2×10^{-5}	Coal trace @61.7'; fractures @ 59.5, 60.2, 65.5'; sandstone @ 68.5-71.9'
	72.5 - 83.5		(no take zone)	--	No sandstone or fractures noted
	82-5 - 93.5		3.0×10^{-3} W ?	1.1×10^{-6}	Sandstone layer @ 83.5 - 84.6'
B-3 (523)	22.0 - 33.0	19'	0.33 W	1.2×10^{-4}	Fracture @18, 21'; sandstone @26 - 26.8'
	32.0 - 43.0		4.9×10^{-3} W ?	1.7×10^{-6}	Sandstone @ 35.9 - 36.9'
	42.0 - 53.0		8.5×10^{-3} W ?	3.0×10^{-6}	Fracturing in high organic zone @ 49'
	52.0 - 63.0		--	--	No fractures or sandstone
B-4 (524)	16.5 - 28.0	12'	5.7 W	2.0×10^{-3}	Some fractures
	26.5 - 37.5		0.26 F/S	9.1×10^{-5}	Some fractures
	36.5 - 57.5		1.4×10^{-3}	4.8×10^{-7}	Fracture @45.5'; sandstone @55.7 - 56.3'
	55.7 - 76.7		--	--	Sandstone @55.7 - 56.3', 71.8 - 73.5'
	76.7 - 97.6		--	--	No sandstone or fractures
	97.0 - 118.0		0.02 F/S	6.6×10^{-6}	Sandstone @108.7 - 111.4'; 113.5 - 116.5'
	116.8 - 122.8		5.2×10^{-3} W	1.8×10^{-6}	No sandstone or fractures
B-5[b] (525)	30.0 - 41.0	~6'	0.02 W	5.5×10^{-6}	No fractures or sandstone noted
	40.0 - 51.0		9.7×10^{-3}	3.4×10^{-6}	Gauge zone in fracture @ 46.8'
	50.0 - 61.0		0.19 F/S	6.6×10^{-5}	Sandstone @ 54-55.2'; fracture @ 55.8'
	60.0 - 71.0		0.33 F/S	1.2×10^{-4}	Sandstone @ 70-73'
	70.0 - 81.0		2.1×10^{-3} W ?	7.3×10^{-7}	Sandstone @ 70-73'
	80.0 - 91.0		0.10 F	3.4×10^{-5}	Sandstone @ 83.1 - 85.5'
	90.0 - 101.0		9.6×10^{-4} W ?	3.4×10^{-7}	Sandstone @ 94.2 - 96.5'
	100.0 - 110.0		--	--	Sandstone @ 101 - 102'
	110.0 - 121.0		9.6×10^{-4} W ?	3.4×10^{-7}	Sandstone @ 110.2 - 111'; coal @ 118.1'
619 MENEFEE TEST	97.0 - 97.6		0.3 (MEAN OF 2 ANALYSES)	1.1×10^{-4}	SILTSTONE + 2' COAL SEAM AND 3' COAL SEAM

L.M. COONS PE, PHG

OCT '90

8/17/

Table 3 Summary of Dames & Moore Packer test data for Bodo Canyon boreholes in the Cliff House Formation (Concluded)

Boring number	Depth of tested interval (ft)	DEPTH TO BEDROCK	Mean conductivity ft/day	Mean conductivity cm/sec	Lithology of tested interval (from boring logs)[a]
B-6	44.0 - 55.0	40	0.17	6.1×10^{-5}	Sandstone @ 48.7 - 50'
	54.0 - 75.0		4.1×10^{-3}	1.5×10^{-6}	Infrequent fractures from 67-80'
	74.0 - 100.0		2.7×10^{-4}	9.7×10^{-8}	Sandstone @ 82.5 - 83.3'; 98.3 - 98.9'
B-7	19.0 - 30.0	10'	1.4	5.1×10^{-4}	Fractures between 10 - 24.5'
	29.0 - 40.0		--	--	No sandstone or fractures noted
B-8	14.0 - 25.0	2'	2.6	9.1×10^{-4}	Sandstone @ 19.6 - 20.3', 23.2 - 23.7'
	24.0 - 35.0		1.4	4.8×10^{-4}	Fractures @ 28.9', 29.6'; sandstone @29.0 - 29.8'
	34.0 - 40.0		0.06	2.0×10^{-5}	Sandstone @ 36.8 - 37.7'
B-9	10.0 - 21.0	3'	1.4	4.8×10^{-4}	No sandstone or fractures noted
	20.0 - 31.0		0.45	1.6×10^{-4}	No sandstone or fractures noted
	30.0 - 41.0		0.10	3.4×10^{-5}	Weathered fractures @ 32.6 - 37.0'
B-10	9.0 - 20.0	3'	1.4	5.1×10^{-4}	Weathered zones @ 9.6 - 9.9'; 12.6 - 12.7'; fractures
	19.0 - 35.0		0.23	8.1×10^{-5}	Fractures from 5.0 - 26.3'; sandstone @ 23.6 - 25.9'
B.11	9.0 - 20.0	3'	0.46	1.6×10^{-4}	Sandstone layer @ 18.1 - 21.5'
	19.0 - 30.0		2.0	7.1×10^{-4}	Sandstone @18.1 - 21.5'; fractures 28.4 - 34.4'
	29.0 - 40.0		3.2	1.1×10^{-3}	Fractures @ 36.2', 38.1 - 38.3'
	39.0 - 50.0		5.8×10^{-3}	2.0×10^{-6}	Fracture @ 43.8'

[a]Note: All borings completed in Cliff House Sandstone formation, a dark grey to black sandy shale with fractures and sandstone layers occurring at indicated depths. Fracture zones weathered or in-filled to varying degrees.

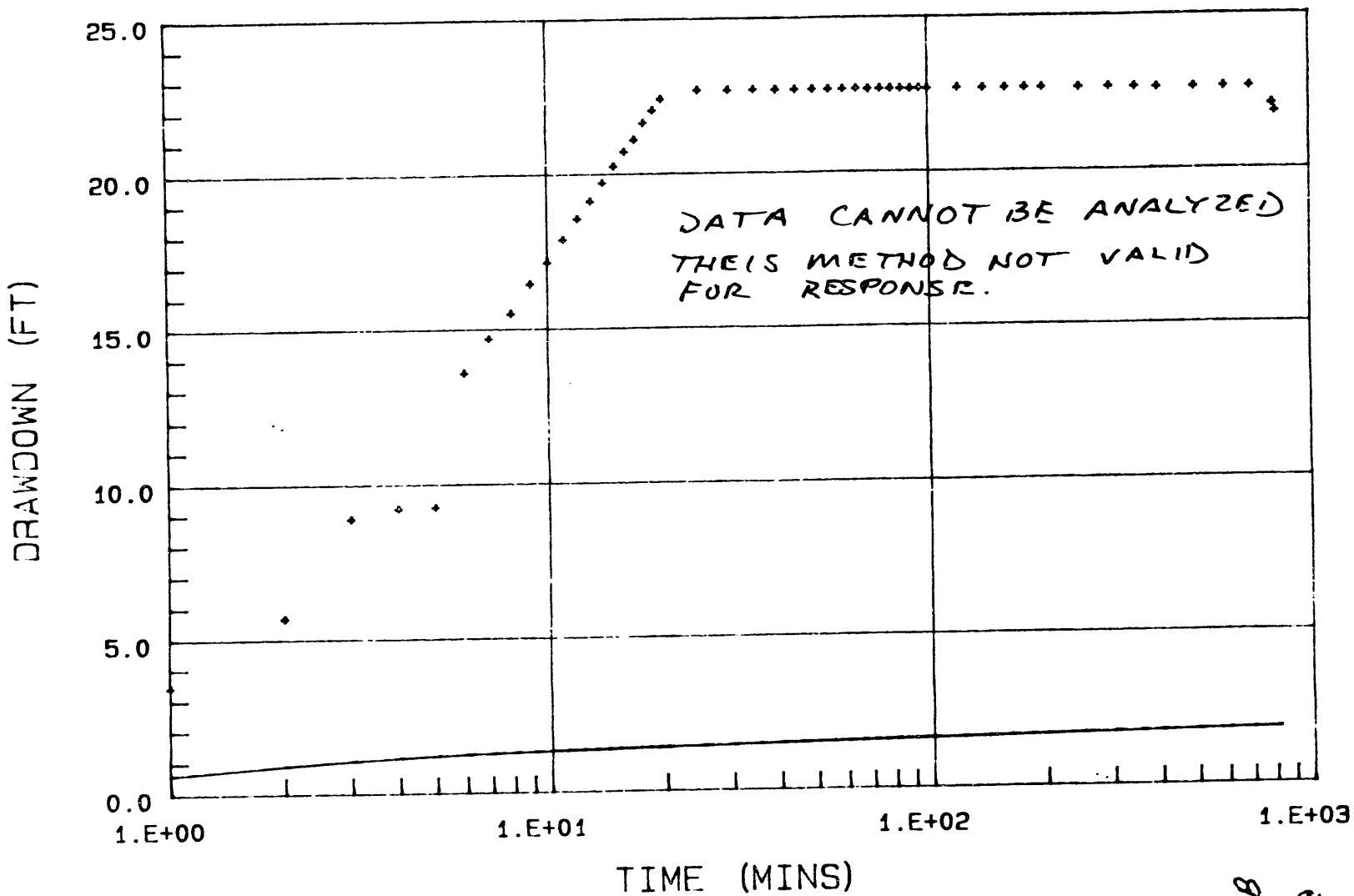
[b]This boring (B-5) may extend into the Menefee Formation; note coal layer @ 118.1'.

[c]See Figure for boring locations.

OCT '90
L.M. COCHRANE, PHB

FIGURE 1.

PUMPING WELL 617



L.M. COOKS P.E. PHG

OCT '90

10/5/90

10/15/9

8/24/91

JACOBS ENGINEERING

L.M. COONS PE, PHg

OCT '90

12 ~~8~~/~~92~~ 7/3
CAP
10/2/90

DATE _____ SUBJECT

BY _____ CHKD. _____

SHEET NO. _____

JOB NO. _____

KAL
10/3/90
ETM
8/29/91

ATTACHMENT A

AQUIFER TEST ANALYSIS
MONITOR WELL 608

FORM 91-005-1 (4/81)

PUMPING WELL 608

L.M. COONS PE, PHG

OCT '90

Cap 10/5/

KAL 10/5

INTERACTIVE PARAMETER ESTIMATION
SUMMARY OF WELL DATA:

PUMPING WELLS					OBSERVATION WELLS						
			AVE					MAX HEAD	-TIME WINDOW-		
No.	X	Y	Q	ON	No.	X	Y	CHG	MIN	MAX	ON
1	0.	0.	0.0	Y	1	0.	0.	3.3	11.	1023.	Y

Maximum head change is the extreme value in the drawdown data set.

ETM 8/29/

PRESS RETURN TO CONTINUE ...

WHIP INT. PAR. EST. - BOUNDARY OPTION HGC INC.

1 - NO BOUNDARY
2 - LINEAR NO-FLOW BOUNDARY <---
3 - LINEAR RECHARGE BOUNDARY

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

WHIP INT. PAR. EST. - AQUIFER TYPE OPTION HGC INC.

1 - HOMOGENEOUS AQUIFER <---
2 - DOUBLE POROSITY AQUIFER
3 - VERT. ANISOTROPIC LEAKY AQUIFER
WITH PARTIAL PENETRATION

PUMPING WELL 608

14 of 13
Cap
10/5/90
KAL
10/5/92
ETM
2/24/91

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

... COONS PE, PHG
OCT '90

WHIP INT. PAR. EST. - HOMOGENOUS AQUIFER HGC INC.

1 - TRANSMISSIVITY	:	270.	(FT2/DAY)
2 - STORATIVITY	:	0.188	
3 - AQUITARD SPECIFIC LEAKAGE	:	0.000	(1/DAY)
4 - INIT. SAT. THICKNESS (DUPUIT ON)	:	7.00	(FT)
5 - PERPENDICULAR DIST. TO BOUNDARY	:	20.0	(FT)
6 - COUNTER-CLOCKWISE ANGLE TO BOUND	:	0.100E-03	(DEGS)

0 - BACK TO PREVIOUS MENU

ENTER OPTION NUMBER >

WHIP PROPERTIES OF PUMP WELLS HGC INC.

PUMP WELL #	PUMP WELL RADIUS (FT)	CASING EFFECTIVE RADIUS (FT)	WELLBORE SKIN	WELL LOSS CONSTANT	WELL LOSS EXPONENT
1	0.330	0.170	0.000	0.000	0.000

0 - BACK TO MAIN MENU

ENTER OPTION >

PUMPING WELL 608

10 A-1 Cof 10/5/ VAL 10/5/ FTM 8/2

OCT '90

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OPTIMIZATION BY LEVENBERG-MARQUARDT MINIMIZATION ALGORITHM

ITER  FUNCTION  TRANSMISS STORTIVTY BDRY_DIST
   1  .249E-02  270.2     .1877     20.00

TERMINATION DUE TO PARAMETER CONVERGENCE

FINAL RESULTS
ITER  FUNCTION  TRANSMISS STORTIVTY BDRY_DIST
   6  .249E-02  270.7     .1879     20.00
FRACTIONAL COMPONENTS OF FUNCTION VALUE
WELL #     1
       1.000

DO YOU WANT A SENSITIVITY ANALYSIS ? (Y/N)
```

SENSITIVITY ANALYSIS

TWO STANDARD DEVIATION CONFIDENCE INTERVALS

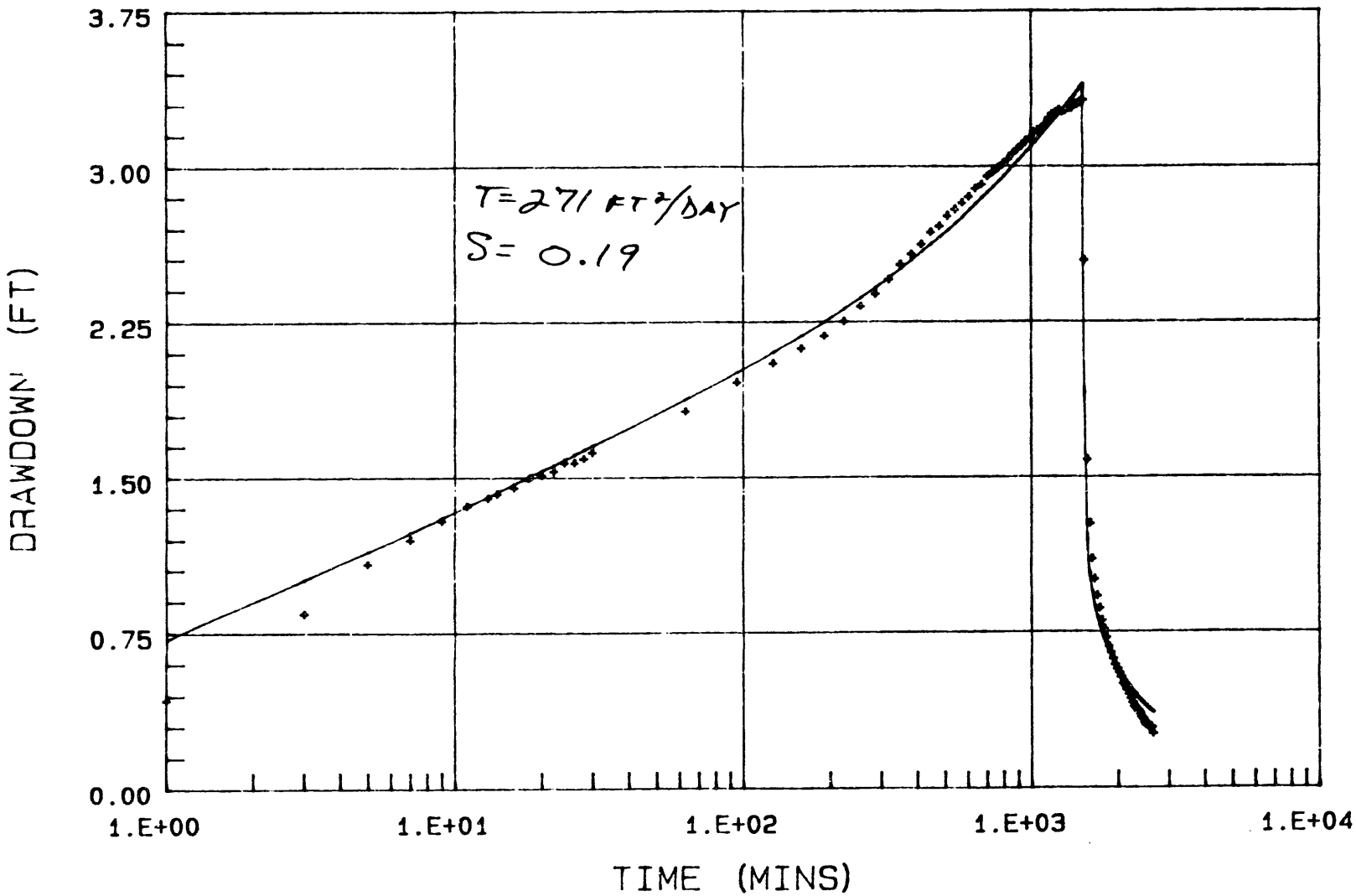
PARAMETER	VALUE	LOWER LIMIT	UPPER LIMIT
TRANSMISS	270.7	0.0000	1881.
STORTIVTY	.1879	0.0000	89.85
BDRY_DIST	20.00	0.0000	347.8

CORRELATION BETWEEN STORTIVTY AND BDRY_DIST IS 1.000

TO CONTINUE ENTER "RETURN"

;IN;DF;SP1;PU;PA0,0;LT;LT;SP1;LT;PU;PA9071,1526;SP1;PD;PA9071,6377;PU;PA187

PUMP WELL 608, IPE - NO FLO BOUND



PLOT FILE: 608PP

L.M. COOKS PE, PHG

OCT '90

10/5/90

KAL 10/5/90

ETM 8/24/91

12 AM/PM

PUMPING WELL 608 RECOVERY

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WHIP                        RECOVERY ANALYSIS                    HGC INC.
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë
         1 - WORK WITH DOS & DATA FILES
         2 - CHOOSE OBS WELLS TO PLOT / DATA SUMMARY :
         3 - CHOOSE DRAWDOWN TRANSFORMATION          :      NONE
         4 - CHOOSE TIME     TRANSFORMATION          :  T/TPRIME
         5 - PLOT ESTIMATED RECOVERY CURVES (?)      :       YES
         6 - PLOT SPECIFIED RECOVERY CURVES (?)      :       YES
         7 - CHANGE PLOT PARAMETERS
         8 - PLOT THE PUMPING RATE DATA
         9 - PLOT THE DRAWDOWN DATA
        10 - STORE PUMPRATE GRAPH TO PLOTTER FILE
        11 - STORE DRAWDOWN GRAPH TO PLOTTER FILE
        12 - OBSERV WELL TO ANALYZE      : WELL #      1
        13 - PUMP WELL FOR ANALYSIS      : WELL #      1
        14 - SET DATA WINDOW             : T/TP MIN = 2.000
                                         : T/TP MAX = 1020.
        15 - ESTIMATE TRANS FROM DATA    : TRANS    = 143.8    FT»/D
        16 - USER SPECIFIED TRANSMISS    : TRANS    = 150.0    FT»/D
        17 - USER SPECIFIED STORATIVITY  : STOR     = .1900    FT»/D
             (REQD. FOR RECOVERY CURVES)
        18 - SUMMARY OF ESTIMATED TRANS VALUES

        0 - BACK TO PREVIOUS MENU
        ENTER OPTION >
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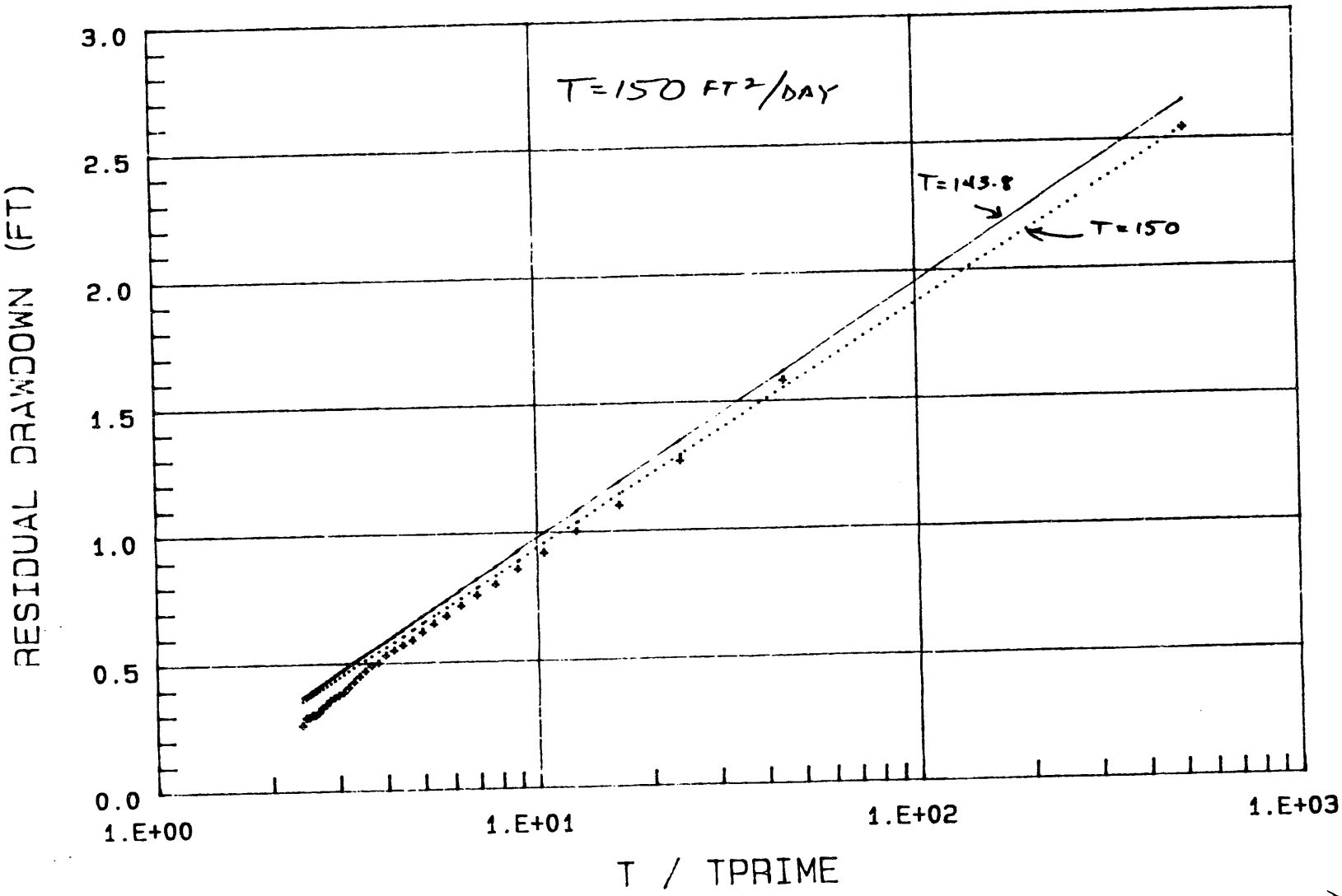
KAL 10/5

ETR 8/2

OCT '90

PUMP WELL 608, DIAGNOSTIC RECOVERY



PLOT FILE: 608R

L.M. COONS PE, PHG

OCT '90

10/5/90
KAC
10/5/90
ETM
8/25/9

BODO CANYON ALLUVIUM AQUIFER TEST, 1989:
OBSERVATION WELL 608, PUMPING WELL ~~[illegible]~~ 608
DRAWDOWN AND RECOVERY DATA FOR ~~MONITOR~~ PUMPING WELL 608

LAW GROUP PE P.A.
OCT '90

Cal
10/3
KAL
10/31
ETM
8/29/9

NUMBER	TIME (MINS)	OBSERVED DRAWDOWN (FT)	COMPUTED DRAWDOWN (FT)	DIFFERENCE (FT)
1	1.000	0.430	0.280	0.150
2	3.000	0.840	0.654	0.186
3	5.000	1.080	0.862	0.218
4	7.000	1.200	1.001	0.199
5	9.000	1.290	1.105	0.185
6	11.000	1.360	1.188	0.172
7	13.000	1.400	1.256	0.144
8	14.000	1.420	1.286	0.134
9	16.000	1.450	1.341	0.109
10	18.000	1.490	1.389	0.101
11	20.000	1.510	1.432	0.078
12	22.000	1.530	1.471	0.059
13	24.000	1.570	1.507	0.063
14	26.000	1.570	1.539	0.031
15	28.000	1.590	1.569	0.021
16	30.000	1.620	1.597	0.023
17	63.000	1.820	1.900	-0.080
18	95.000	1.960	2.067	-0.107
19	127.000	2.050	2.185	-0.135
20	159.000	2.120	2.277	-0.157
21	191.000	2.180	2.352	-0.172
22	223.000	2.250	2.415	-0.165
23	255.000	2.320	2.470	-0.150
24	287.000	2.380	2.519	-0.139
25	319.000	2.450	2.562	-0.112
26	351.000	2.520	2.602	-0.082
27	383.000	2.570	2.638	-0.068
28	415.000	2.620	2.671	-0.051
29	447.000	2.680	2.701	-0.021
30	479.000	2.710	2.730	-0.020
31	511.000	2.760	2.757	0.003
32	543.000	2.790	2.782	0.008
33	575.000	2.820	2.805	0.015
34	607.000	2.850	2.828	0.022
35	639.000	2.890	2.849	0.041
36	671.000	2.910	2.869	0.041
37	703.000	2.950	2.889	0.061
38	735.000	2.970	2.907	0.063
39	767.000	2.990	2.925	0.065
40	799.000	3.010	2.942	0.068
41	831.000	3.030	2.958	0.072
42	863.000	3.060	2.974	0.086
43	895.000	3.080	2.989	0.091
44	927.000	3.100	3.003	0.097
45	959.000	3.120	3.017	0.103
46	991.000	3.130	3.031	0.099
47	1023.000	3.160	3.044	0.116
48	1055.000	3.170	3.057	0.113
49	1087.000	3.180	3.070	0.110
50	1119.000	3.200	3.082	0.118
51	1151.000	3.230	3.093	0.137
52	1183.000	3.250	3.105	0.145
53	1215.000	3.260	3.116	0.144
54	1247.000	3.270	3.127	0.143
55	1279.000	3.260	3.137	0.123

L.M. COCHS PE, PHg

OCT '90

10/3/90

KAL 10/3/90

ETM 8/24/91

56	1311.000	3.270	3.148	0.122
57	1343.000	3.280	3.158	0.122
58	1375.000	3.280	3.168	0.112
59	1407.000	3.300	3.177	0.123
60	1439.000	3.300	3.187	0.113
61	1471.000	3.310	3.196	0.114
62	1503.000	3.320	3.205	0.115
COVERY				
63	1535.000	2.540	2.511	0.029
64	1567.000	1.580	1.489	0.091
65	1599.000	1.270	1.236	0.034
66	1631.000	1.100	1.088	0.012
67	1663.000	1.000	0.985	0.015
68	1695.000	0.920	0.907	0.013
69	1727.000	0.860	0.843	0.017
70	1759.000	0.800	0.791	0.009
71	1791.000	0.760	0.747	0.013
72	1823.000	0.720	0.708	0.012
73	1855.000	0.680	0.674	0.006
74	1887.000	0.650	0.644	0.006
75	1919.000	0.620	0.617	0.003
76	1951.000	0.590	0.592	-0.002
77	1983.000	0.570	0.570	0.000
78	2015.000	0.550	0.550	0.000
79	2047.000	0.530	0.531	-0.001
80	2079.000	0.500	0.513	-0.013
81	2111.000	0.490	0.497	-0.007
82	2143.000	0.470	0.482	-0.012
83	2175.000	0.450	0.468	-0.018
84	220[illegible]000	0.430	0.455	-0.025
85	22[illegible].000	0.410	0.443	-0.033
86	22[illegible]1.000	0.390	0.431	-0.041
87	2303.000	0.380	0.420	-0.040
88	2335.000	0.370	0.410	-0.040
89	2367.000	0.360	0.400	-0.040
90	2399.000	0.340	0.391	-0.051
91	2431.000	0.330	0.382	-0.052
92	2463.000	0.310	0.373	-0.063
93	2495.000	0.300	0.365	-0.065
94	2527.000	0.300	0.357	-0.057
95	2559.000	0.290	0.350	-0.060
96	2591.000	0.290	0.343	-0.053
97	2635.000	0.260	0.334	-0.074

JACOBS ENGINEERING

L.M. COCHS PE, PHg

DATE _____ SUBJECT

OCT '90

SHEET NO. 10/5/9

BY _____ CHKD. _____

JOB NO. KAL 10/5/9

EPM 8/29/

ATTACHMENT A1
AQUIFER TEST ANALYSIS
MONITOR WELL 618

FORM 91-005-1 (4/81)

C18 D

22 Ap 08 / 3K
CB
10/5/90

WHIP WELL GEOMETRY HGC INC.

KAL
10/5/90

NO.	WELL TYPE	X-COORDINATE	Y-COORDINATE
1 -	OBS # 1	0.0000	20.5000
2 -	PUMP # 1	0.0000	0.0000

L.M. COOPER PE, PMB

OCT '90 ETM
8/29/91

0 - BACK TO PREVIOUS MENU

ENTER OPTION >

WHIP INT. PAR. EST. - BOUNDARY OPTION HGC INC.

1 - NO BOUNDARY
2 - LINEAR NO-FLOW BOUNDARY <---
3 - LINEAR RECHARGE BOUNDARY

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

WHIP INT. PAR. EST. - AQUIFER TYPE OPTION HGC INC.

1 - HOMOGENEOUS AQUIFER <---
2 - DOUBLE POROSITY AQUIFER
3 - VERT. ANISOTROPIC LEAKY AQUIFER
WITH PARTIAL PENETRATION

GTB D

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

L.M. COOKS PE, PHG

OCT '90

10/5/9

KAL 10/5/9

ETM 8/24/91

WHIP INT. PAR. EST. - HOMOGENOUS AQUIFER HGC INC.

1 - TRANSMISSIVITY	:	280.	(FT2/DAY)
2 - STORATIVITY	:	0.497E-03	
3 - AQUITARD SPECIFIC LEAKAGE	:	0.000	(1/DAY)
4 - INIT. SAT. THICKNESS (DUPUIT ON)	:	7.00	(FT)
5 - PERPENDICULAR DIST. TO BOUNDARY	:	130.	(FT)
6 - COUNTER-CLOCKWISE ANGLE TO BOUND	:	0.100E-03	(DEGS)

0 - BACK TO PREVIOUS MENU

ENTER OPTION NUMBER >

WHIP PROPERTIES OF PUMP WELLS HGC INC.

PUMP WELL #	PUMP WELL RADIUS (FT)	CASING EFFECTIVE RADIUS (FT)	WELLBORE SKIN	WELL LOSS CONSTANT	WELL LOSS EXPONENT
1	0.330	0.170	0.000	0.000	0.000

0 - BACK TO MAIN MENU

ENTER OPTION >

24 ~~A~~ 40/3
Cap
10/5/9

OBSERVATION WELL 618 DRAWDOWN

OPTIMIZATION BY LEVENBERG-MARQUARDT MINIMIZATION ALGORITHM

L.M. COONS DE PHG KAL 10/5/90 ETM 8/29/91

ITER	FUNCTION	TRANSMISS	STORTIVTY	BDRY_DIST
1	.456E-02	280.0	.5000E-03	130.0

TERMINATION DUE TO PARAMETER CONVERGENCE

FINAL RESULTS

ITER	FUNCTION	TRANSMISS	STORTIVTY	BDRY_DIST
6	.456E-02	279.7	.4968E-03	130.0

FRACTIONAL COMPONENTS OF FUNCTION VALUE

WELL # 1

1.000

DO YOU WANT A SENSITIVITY ANALYSIS ? (Y/N)

SENSITIVITY ANALYSIS

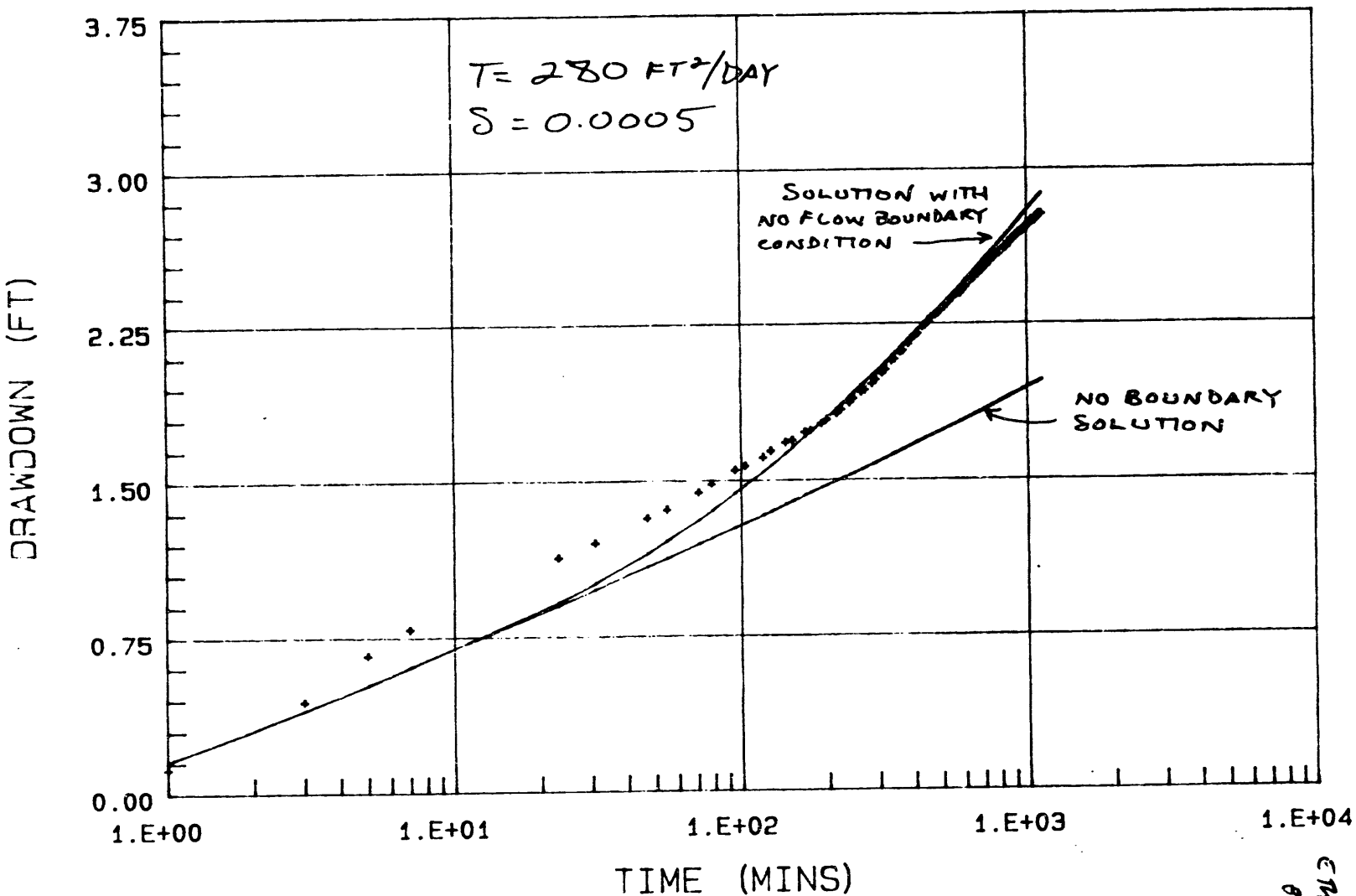
TWO STANDARD DEVIATION CONFIDENCE INTERVALS

PARAMETER	VALUE	LOWER LIMIT	UPPER LIMIT
TRANSMISS	279.7	247.2	312.2
STORTIVTY	.4968E-03	0.0000	22.91
BDRY_DIST	130.0	17.74	242.3

CORRELATION BETWEEN STORTIVTY AND BDRY_DIST IS 1.000

TO CONTINUE ENTER "RETURN"

ALLUVIAL OBS. WELL 618, IPE



L.M. COCHS PE, PHG
OCT '90

JACOBS ENGINEERING

L.M. COONS PE, PHg

OCT '90

DATE _____ SUBJECT

BY _____ CHKD. _____

SHEET NO. _____

JOB NO. _____

ATTACHMENT B

AQUIFER TEST ANALYSIS
MONITOR WELL 620

FORM 91-005 1 (4/81)

OBSERVATION WELL 620
DRAWDOWN
L.M. COONS PE, PHD KAL 10/3/90

DATA FILE: AL620.SAV
PLOT FILE: A620
ETM 8/29/

OCT '90

INTERACTIVE PARAMETER ESTIMATION
SUMMARY OF WELL DATA:

PUMPING WELLS					OBSERVATION WELLS						
No.	X	Y	AVE Q	ON	No.	X	Y	MAX HEAD CHG	-TIME WINDOW- MIN	MAX	ON
1	0.	0.	0.0	Y	1	0.	10.	3.0	1.	1087.	Y

Maximum head change is the extreme value in the drawdown data set.

PRESS RETURN TO CONTINUE ...

WHIP WELL GEOMETRY HGC INC.

NO.	WELL TYPE	X-COORDINATE	Y-COORDINATE
1 -	OBS # 1	0.0000	10.0000
2 -	PUMP # 1	0.0000	0.0000

0 - BACK TO PREVIOUS MENU

ENTER OPTION >

WHIP INT. PAR. EST. - BOUNDARY OPTION HGC INC.

1 - NO BOUNDARY
2 - LINEAR NO-FLOW BOUNDARY <---
3 - LINEAR RECHARGE BOUNDARY

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

24 ~~May/44~~ ~~Oct 3~~
25

Caf
10/3/90

L.M. COONS PE, PHG

OCT '90

KAL
10/3/90

ETM 8/29/91

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     WHIP     INT. PAR. EST.  -  AQUIFER TYPE OPTION     HGC INC.
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

         1 - HOMOGENEOUS AQUIFER                        <---
         2 - DOUBLE POROSITY AQUIFER
         3 - VERT. ANISOTROPIC LEAKY AQUIFER
             WITH PARTIAL PENETRATION

         0 - BACK TO PREVIOUS MENU

         ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >
```

```
     WHIP     INT. PAR. EST.  -  HOMOGENOUS AQUIFER     HGC INC.
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

         1 - TRANSMISSIVITY                     :     195.     (FT2/DAY)
         2 - STORATIVITY                        :    0.109E-02
         3 - AQUITARD SPECIFIC LEAKAGE          :    0.000        (1/DAY)
         4 - EST. MAX. DRAWDOWN (DUPUIT OFF)    :     3.00           (FT)
         5 - PERPENDICULAR DIST. TO BOUNDARY    :     139.           (FT)
         6 - COUNTER-CLOCKWISE ANGLE TO BOUND   :    0.100E-03     (DEGS)
         0 - BACK TO PREVIOUS MENU

         ENTER OPTION NUMBER >
```

DIST. TO BOUNDARY IS OPTIMIZED

6-2-6

L.M. COONS PE. PHg 29

OCT '90

WHIP PROPERTIES OF PUMP WELLS HGC INC.

PUMP WELL #	PUMP WELL RADIUS (FT)	CASING EFFECTIVE RADIUS (FT)	WELLBORE SKIN	WELL LOSS CONSTANT	WELL LOSS EXPONENT
1	0.330	0.170	0.000	0.000	0.000

0 - BACK TO MAIN MENU

ENTER OPTION >

L.M. COONS PE, PHE
OCT '90
L.M. COONS PE, PHE
OCT '90

OPTIMIZATION BY LEVENBERG-MARQUARDT MINIMIZATION ALGORITHM

ITER	FUNCTION	TRANSMISS	STORTIVTY	BDRY_DIST
1	.127E-02	189.4	.1157E-02	142.4
2	.116E-02	199.9	.1020E-02	136.9
3	.115E-02	191.4	.1132E-02	140.8
4	.109E-02	198.0	.1046E-02	137.4
5	.109E-02	192.8	.1115E-02	139.8
7	.106E-02	196.8	.1063E-02	137.8
9	.105E-02	195.2	.1084E-02	138.5

TERMINATION DUE TO PARAMETER CONVERGENCE

FINAL RESULTS

ITER	FUNCTION	TRANSMISS	STORTIVTY	BDRY_DIST
9	.105E-02	194.9	.1088E-02	138.5

FRACTIONAL COMPONENTS OF FUNCTION VALUE
WELL # 1
1.000

DO YOU WANT A SENSITIVITY ANALYSIS ? (Y/N)

SENSITIVITY ANALYSIS

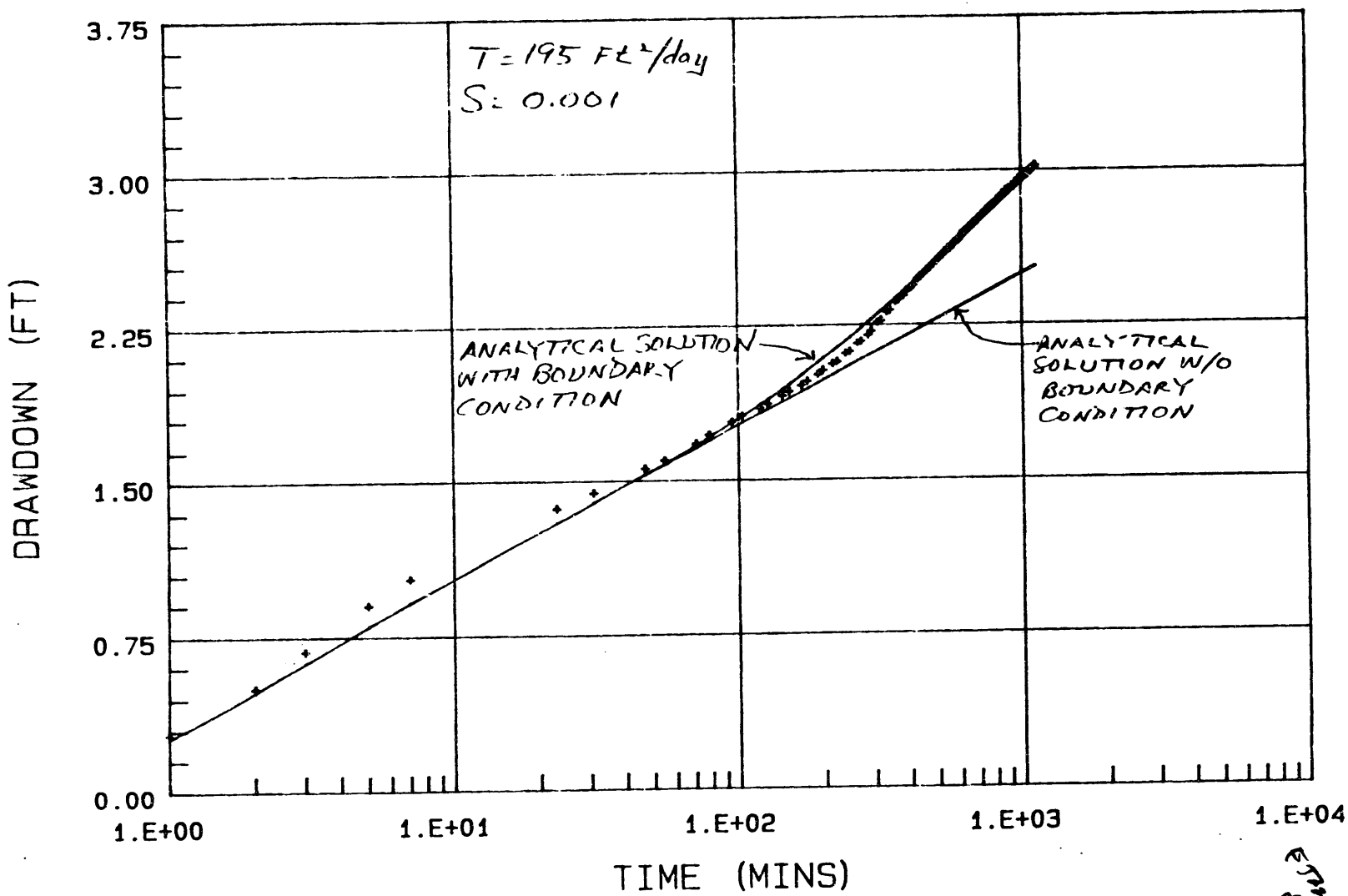
TWO STANDARD DEVIATION CONFIDENCE INTERVALS

PARAMETER	VALUE	LOWER LIMIT	UPPER LIMIT
TRANSMISS	194.9	102.6	287.3
STORTIVTY	.1088E-02	0.0000	2071.
BDRY_DIST	138.6	0.0000	2922.

CORRELATION BETWEEN STORTIVTY AND BDRY_DIST IS 1.000

TO CONTINUE ENTER "RETURN"

ALLUVIAL WELL 620, IPE 1-1100 MINS.



OCT '90

L.M. COLLINS P.E. PHG

10/31

8/29/9

ODO CANYON ALLUVIUM AQUIFER TEST, 1989:
BSERVATION WELL 620, PUMPING WELL 608
RAWDOWN DATA FOR OBSERVATION WELL 620

JMBER	TIME (MINS)	OBSERVED DRAWDOWN (FT)	COMPUTED DRAWDOWN (FT)	DIFFERENCE (FT)
1	1.000	0.280	0.071	0.209
2	2.000	0.500	0.211	0.289
3	3.000	0.680	0.342	0.338
4	5.000	0.900	0.551	0.349
5	7.000	1.030	0.704	0.326
6	23.000	1.370	1.254	0.116
7	31.000	1.440	1.388	0.052
8	47.000	1.560	1.571	-0.011
9	55.000	1.600	1.639	-0.039
10	71.000	1.680	1.749	-0.069
11	79.000	1.720	1.795	-0.075
12	95.000	1.780	1.874	-0.094
13	103.000	1.810	1.908	-0.098
14	119.000	1.850	1.970	-0.120
15	127.000	1.870	1.998	-0.128
16	143.000	1.910	2.048	-0.138
17	151.000	1.930	2.071	-0.141
18	167.000	1.960	2.114	-0.154
19	175.000	1.980	2.134	-0.154
20	191.000	2.010	2.170	-0.160
21	199.000	2.030	2.188	-0.158
22	215.000	2.060	2.220	-0.160
23	223.000	2.070	2.236	-0.166
24	239.000	2.110	2.265	-0.155
25	247.000	2.120	2.279	-0.159
26	263.000	2.160	2.305	-0.145
27	271.000	2.170	2.318	-0.148
28	287.000	2.200	2.342	-0.142
29	295.000	2.220	2.354	-0.134
30	311.000	2.260	2.376	-0.116
31	319.000	2.270	2.386	-0.116
32	335.000	2.310	2.407	-0.097
33	343.000	2.320	2.417	-0.097
34	359.000	2.360	2.436	-0.076
35	367.000	2.370	2.445	-0.075
36	383.000	2.390	2.463	-0.073
37	391.000	2.410	2.472	-0.062
38	407.000	2.430	2.489	-0.059
39	415.000	2.440	2.497	-0.057
40	431.000	2.470	2.513	-0.043
41	439.000	2.480	2.520	-0.040
42	455.000	2.500	2.535	-0.035
43	463.000	2.510	2.543	-0.033
44	479.000	2.530	2.557	-0.027
45	487.000	2.540	2.564	-0.024
46	503.000	2.560	2.577	-0.017
47	511.000	2.570	2.584	-0.014
48	527.000	2.590	2.597	-0.007
49	535.000	2.600	2.603	-0.003
50	551.000	2.620	2.616	0.004
51	559.000	2.620	2.622	-0.002
52	575.000	2.640	2.633	0.007
53	583.000	2.650	2.639	0.011
54	599.000	2.660	2.651	0.009
55	607.000	2.670	2.656	0.014

10/2/90
10/3/90
8/29/91
L.M. COONS PE, PHR
OCT '90

56	623.000	2.690	2.667	0.023
57	631.000	2.700	2.672	0.028
58	647.000	2.710	2.683	0.027
59	655.000	2.720	2.688	0.032
60	671.000	2.730	2.698	0.032
61	679.000	2.740	2.703	0.037
62	695.000	2.750	2.713	0.037
63	703.000	2.760	2.718	0.042
64	719.000	2.770	2.727	0.043
65	727.000	2.780	2.732	0.048
66	743.000	2.790	2.741	0.049
67	751.000	2.800	2.745	0.055
68	767.000	2.810	2.754	0.056
69	775.000	2.820	2.758	0.062
70	791.000	2.830	2.767	0.063
71	799.000	2.830	2.771	0.059
72	815.000	2.840	2.779	0.061
73	823.000	2.850	2.783	0.067
74	839.000	2.860	2.791	0.069
75	847.000	2.870	2.795	0.075
76	863.000	2.880	2.803	0.077
77	871.000	2.880	2.807	0.073
78	887.000	2.900	2.815	0.085
79	895.000	2.900	2.818	0.082
80	911.000	2.910	2.826	0.084
81	919.000	2.910	2.830	0.080
82	935.000	2.920	2.837	0.083
83	943.000	2.920	2.840	0.080
84	959.000	2.940	2.847	0.093
85	967.000	2.940	2.851	0.089
86	983.000	2.950	2.858	0.092
87	991.000	2.950	2.861	0.089
88	1007.000	2.970	2.868	0.102
89	1015.000	2.960	2.871	0.089
90	1031.000	2.970	2.878	0.092
91	1039.000	2.980	2.881	0.099
92	1055.000	2.980	2.887	0.093
93	1063.000	2.990	2.890	0.100
94	1079.000	3.000	2.897	0.103
95	1087.000	3.000	2.900	0.100
96	1103.000	3.010	2.906	0.104
97	1110.000	3.010	2.908	0.102
98	1121.000	3.020	2.912	0.108

10/1/9

KAL

ETM 10/3/90

8/29/

L.M. COBBS PE, PHG

OCT '90

JACOBS ENGINEERING

DATE _____ SUBJECT

BY _____ CHKD. _____

34 34 380/2/2 ~~26.13~~ Cap

SHEET NO. 10/8/9

JOB NO. KAL 10/3/90

ETM 8/29/91

L.M. COMPTE, PHG

OCT '90

ATTACHMENT C

AQUIFER TEST ANALYSIS
MONITOR WELL 619

FORM 91-005-1 (4/81)

OBSERVATION WELL 619
DRAWDOWN

DATA FILE: BD619.SAV
PLOT FILE: AL619

INTERACTIVE PARAMETER ESTIMATION
SUMMARY OF WELL DATA:

PUMPING WELLS					OBSERVATION WELLS						
No.	X	Y	AVE Q	ON	No.	X	Y	MAX HEAD CHG	-TIME WINDOW- MIN	MAX	ON
1	0.	0.	0.0	Y	1	0.	11.	4.0	10.	1000.	Y

Maximum head change is the extreme value in the drawdown data set.

PRESS RETURN TO CONTINUE ...

L.M. COLLINS PE, PHG
OCT '90 8/2

WHIP WELL GEOMETRY HGC INC.

NO.	WELL TYPE	X-COORDINATE	Y-COORDINATE
1 -	OBS # 1	0.0000	10.6000
2 -	PUMP # 1	0.0000	0.0000

0 - BACK TO PREVIOUS MENU

ENTER OPTION >

WHIP INT. PAR. EST. - BOUNDARY OPTION HGC INC.

1 - NO BOUNDARY
2 - LINEAR NO-FLOW BOUNDARY
3 - LINEAR RECHARGE BOUNDARY <---

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

36 ~~35/~~ 35

L.M. COONS PE, PHE 10/2/90

OCT '90 KAL 10/3/90

FTK 8/29/91

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       WHIP     INT. PAR. EST.   -   AQUIFER TYPE OPTION     HGC INC.
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

       1 - HOMOGENEOUS AQUIFER                      <---
       2 - DOUBLE POROSITY AQUIFER
       3 - VERT. ANISOTROPIC LEAKY AQUIFER
           WITH PARTIAL PENETRATION

       0 - BACK TO PREVIOUS MENU

       ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >
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       WHIP     INT. PAR. EST.   -   HOMOGENOUS AQUIFER     HGC INC.
ëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëëë

       1 - TRANSMISSIVITY                      :      7.84    (FT2/DAY)
       2 - STORATIVITY                         :     0.378E-03
       3 - AQUITARD SPECIFIC LEAKAGE           :     0.000      (1/DAY)
       4 - EST. MAX. DRAWDOWN (DUPUIT OFF)     :      3.75         (FT)
       5 - PERPENDICULAR DIST. TO BOUNDARY     :      30.0         (FT)
       6 - COUNTER-CLOCKWISE ANGLE TO BOUND :         12.7       (DEGS)
       0 - BACK TO PREVIOUS MENU

       ENTER OPTION NUMBER >
```

WHIP PROPERTIES OF PUMP WELLS HGC INC.

PUMP WELL #	PUMP WELL RADIUS (FT)	CASING EFFECTIVE RADIUS (FT)	WELLBORE SKIN	WELL LOSS CONSTANT	WELL LOSS EXPONENT
1	0.330	0.170	0.000	0.000	0.000

0 - BACK TO MAIN MENU

ENTER OPTION >

L.M. COONS PL. PI.
OCT '90

OPTIMIZATION BY LEVENBERG-MARQUARDT MINIMIZATION ALGORITHM

ITER	FUNCTION	TRANSMISS	STORTIVTY
1	.160E-01	7.838	.3783E-03

TERMINATION DUE TO PARAMETER CONVERGENCE

FINAL RESULTS

ITER	FUNCTION	TRANSMISS	STORTIVTY
1	.160E-01	7.830	.3803E-03

FRACTIONAL COMPONENTS OF FUNCTION VALUE

WELL # 1

1.000

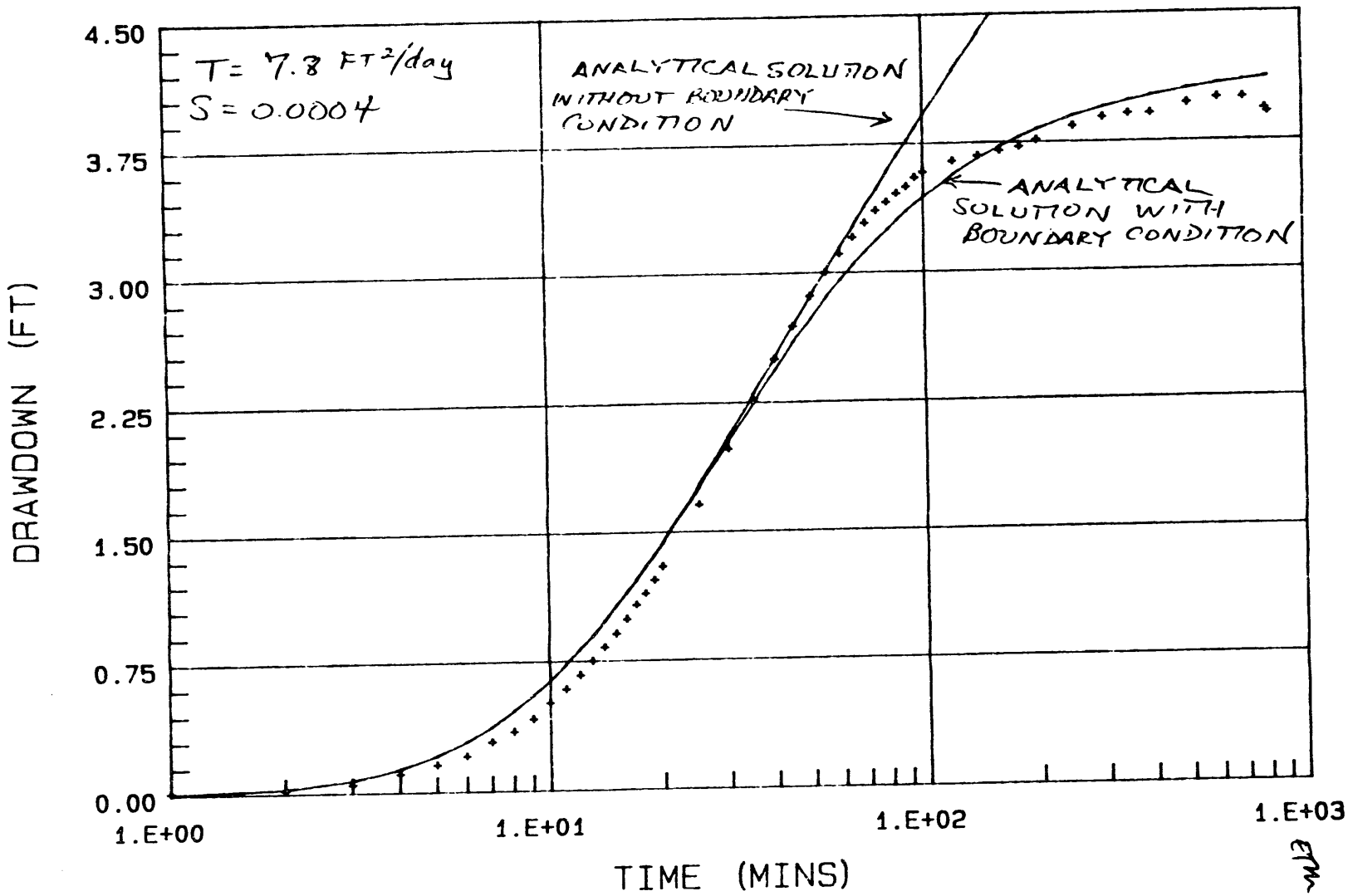
DO YOU WANT A SENSITIVITY ANALYSIS ? (Y/N)

SENSITIVITY ANALYSIS

TWO STANDARD DEVIATION CONFIDENCE INTERVALS

PARAMETER	VALUE	LOWER LIMIT	UPPER LIMIT
TRANSMISS	7.830	2.300	13.36
STORTIVTY	.3803E-03	0.0000	0.1537E-02

MENEFEE WELL 619, HOMO AQ., RECH. BOUND.



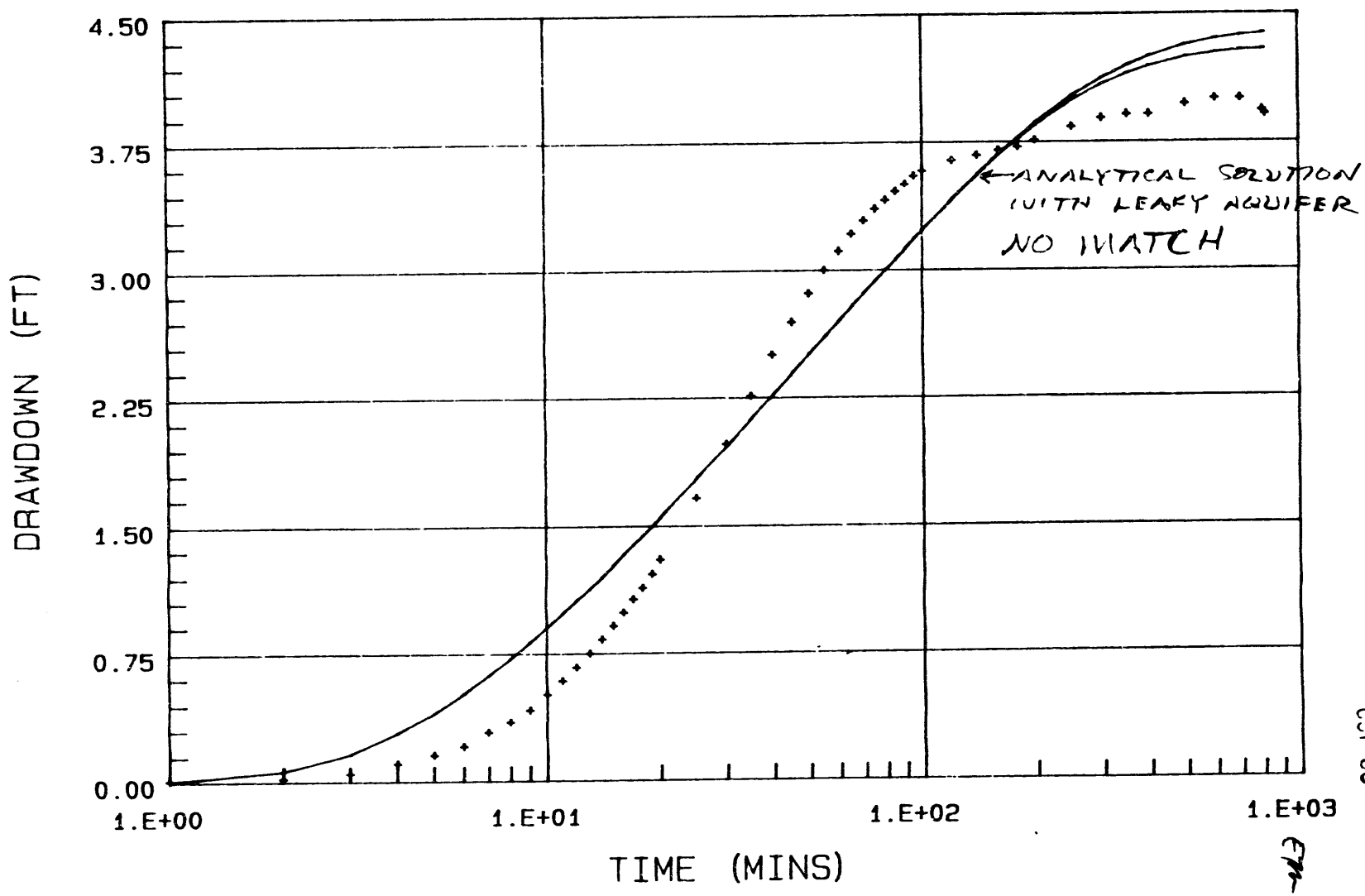
L.M. COONS PE, PHE

10/3/90

KAC 10/3/90

ETM 8/29/9

MENEFEE WELL 619, LEAKY AQ., RECH. BOUND



L.M. COONS PE, PHG

OCT '90

8/29/

DO CANYON CLIFF HOUSE/MENEFEE AQUIFER TEST, 1989:
SERVATIN WELL 619, PUMPING WELL 617
AWDOWN DATA FOR OBSERVATION WELL 619

37 40 Cap
10/5/90
KH 10/3/90

L.M. COONS PE. PHE

OCT '90 ETM
8/29/91

JMBER	TIME (MINS)	OBSERVED DRAWDOWN (FT)	COMPUTED DRAWDOWN (FT)	DIFFERENCE (FT)
1	1.000	0.010	0.035	-0.025
2	2.000	0.020	0.100	-0.080
3	3.000	0.050	0.174	-0.124
4	4.000	0.110	0.252	-0.142
5	5.000	0.160	0.332	-0.172
6	6.000	0.210	0.412	-0.202
7	7.000	0.290	0.492	-0.202
8	8.000	0.350	0.572	-0.222
9	9.000	0.420	0.650	-0.230
10	10.000	0.510	0.727	-0.217
11	11.000	0.590	0.803	-0.213
12	12.000	0.670	0.877	-0.207
13	13.000	0.750	0.949	-0.199
14	14.000	0.830	1.020	-0.190
15	15.000	0.910	1.089	-0.179
16	16.000	0.990	1.156	-0.166
17	17.000	1.070	1.222	-0.152
18	18.000	1.140	1.286	-0.146
19	19.000	1.220	1.348	-0.128
20	20.000	1.300	1.409	-0.109
21	25.000	1.660	1.689	-0.029
22	30.000	1.980	1.934	0.046
23	35.000	2.260	2.147	0.113
24	40.000	2.500	2.335	0.165
25	45.000	2.690	2.499	0.191
26	50.000	2.860	2.643	0.217
27	55.000	3.000	2.770	0.230
28	60.000	3.110	2.882	0.228
29	65.000	3.210	2.982	0.228
30	70.000	3.290	3.070	0.220
31	75.000	3.360	3.149	0.211
32	80.000	3.410	3.219	0.191
33	85.000	3.460	3.282	0.178
34	90.000	3.500	3.338	0.162
35	95.000	3.550	3.389	0.161
36	100.000	3.580	3.434	0.146
37	120.000	3.640	3.577	0.063
38	140.000	3.670	3.675	-0.005
39	160.000	3.700	3.745	-0.045
40	180.000	3.720	3.796	-0.076
41	200.000	3.760	3.834	-0.074
42	250.000	3.840	3.897	-0.057
43	300.000	3.890	3.934	-0.044
44	350.000	3.910	3.957	-0.047
45	400.000	3.910	3.976	-0.066
46	500.000	3.970	3.998	-0.028
47	600.000	4.000	4.011	-0.011
48	700.000	4.000	4.020	-0.020
49	800.000	3.930	4.027	-0.097
50	814.000	3.910	4.028	-0.118

OBSERVATION WELL 619
RECOVERY

REC 619.SAL
PLOT FILE:
619R

INTERACTIVE PARAMETER ESTIMATION
SUMMARY OF WELL DATA:

PUMPING WELLS					OBSERVATION WELLS						
No.	X	Y	AVE Q	ON	No.	X	Y	MAX HEAD CHG	-TIME WINDOW- MIN	MAX	ON
1	0.	0.	0.0	Y	1	10.	0.	3.9	814.	1454.	Y

Maximum head change is the extreme value in the drawdown data set.

PRESS RETURN TO CONTINUE ...

L.M. COOPER PHE

OCT '90

WHIP INT. PAR. EST. - BOUNDARY OPTION HGC INC.

1 - NO BOUNDARY
2 - ~~LINEAR NO-FLOW BOUNDARY~~
3 - LINEAR RECHARGE BOUNDARY <---

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

WHIP INT. PAR. EST. - AQUIFER TYPE OPTION HGC INC.

1 - HOMOGENEOUS AQUIFER
2 - DOUBLE POROSITY AQUIFER
3 - VERT. ANISOTROPIC LEAKY AQUIFER <---
~~WITH PARTIAL PENETRATION~~

0 - BACK TO PREVIOUS MENU

ENTER NUMBER TO CHANGE THE DISPLAYED OPTION >

L.M. COONS PE, PHB

OCT '90

10/8/90

KAL 10/3/90

ETM 8/29/

WHIP INT. PAR. EST. - VERT ANISO LEAKY AQUIFER : MENU 1 HGC INC.

1 - TRANSMISSIVITY	:	7.04	(FT2/DAY)
2 - STORATIVITY	:	0.189E-02	
3 - AQUIFER VERT HYD CONDUCTIVITY	:	0.100	(FT/DAY)
4 - AQUITARD VERT HYD CONDUCTIVITY	:	0.000	(FT/DAY)
5 - AQUITARD SPECIFIC STORAGE	:	0.000	(1/FT)
6 - DEPTH TO BASE OF AQUIFER	:	92.0	(FT)
7 - DEPTH TO TOP OF AQUIFER	:	67.0	(FT)
8 - DEPTH TO TOP OF CONFINING LAYER	:	52.0	(FT)
9 - PERPENDICULAR DIST. TO BOUNDARY	:	30.0	(FT)
10 - COUNTER-CLOCKWISE ANGLE TO BOUND	:	0.100E-03	(DEGS)

11 - CONTINUE TO NEXT PARAMETER MENU PAGE
12 - GO TO CONVERGENCE PARAMETERS MENU

ENTER OPTION NUMBER >

WHIP PROPERTIES OF PUMP WELLS HGC INC.

PUMP WELL #	PUMP WELL RADIUS (FT)	CASING EFFECTIVE RADIUS (FT)	WELLBORE SKIN	WELL LOSS CONSTANT	WELL LOSS EXPONENT
1	0.330	0.170	0.000	0.000	0.000

0 - BACK TO MAIN MENU

ENTER OPTION >

OPTIMIZATION BY LEVENBERG-MARQUARDT MINIMIZATION ALGORITHM

ITER	FUNCTION	TRANSMISS	STORTIVTY
1	.184E-01	7.045	.1888E-02

TERMINATION DUE TO PARAMETER CONVERGENCE

FINAL RESULTS

ITER	FUNCTION	TRANSMISS	STORTIVTY
1	.184E-01	7.046	.1888E-02

FRACTIONAL COMPONENTS OF FUNCTION VALUE
WELL # 1
1.000

DO YOU WANT A SENSITIVITY ANALYSIS ? (Y/N)

SENSITIVITY ANALYSIS

TWO STANDARD DEVIATION CONFIDENCE INTERVALS

PARAMETER	VALUE	LOWER LIMIT	UPPER LIMIT
TRANSMISS	7.046	2.438	11.65
STORTIVTY	.1888E-02	0.0000	0.8703E-02

TO CONTINUE ENTER "RETURN"

KAL 10/3/91

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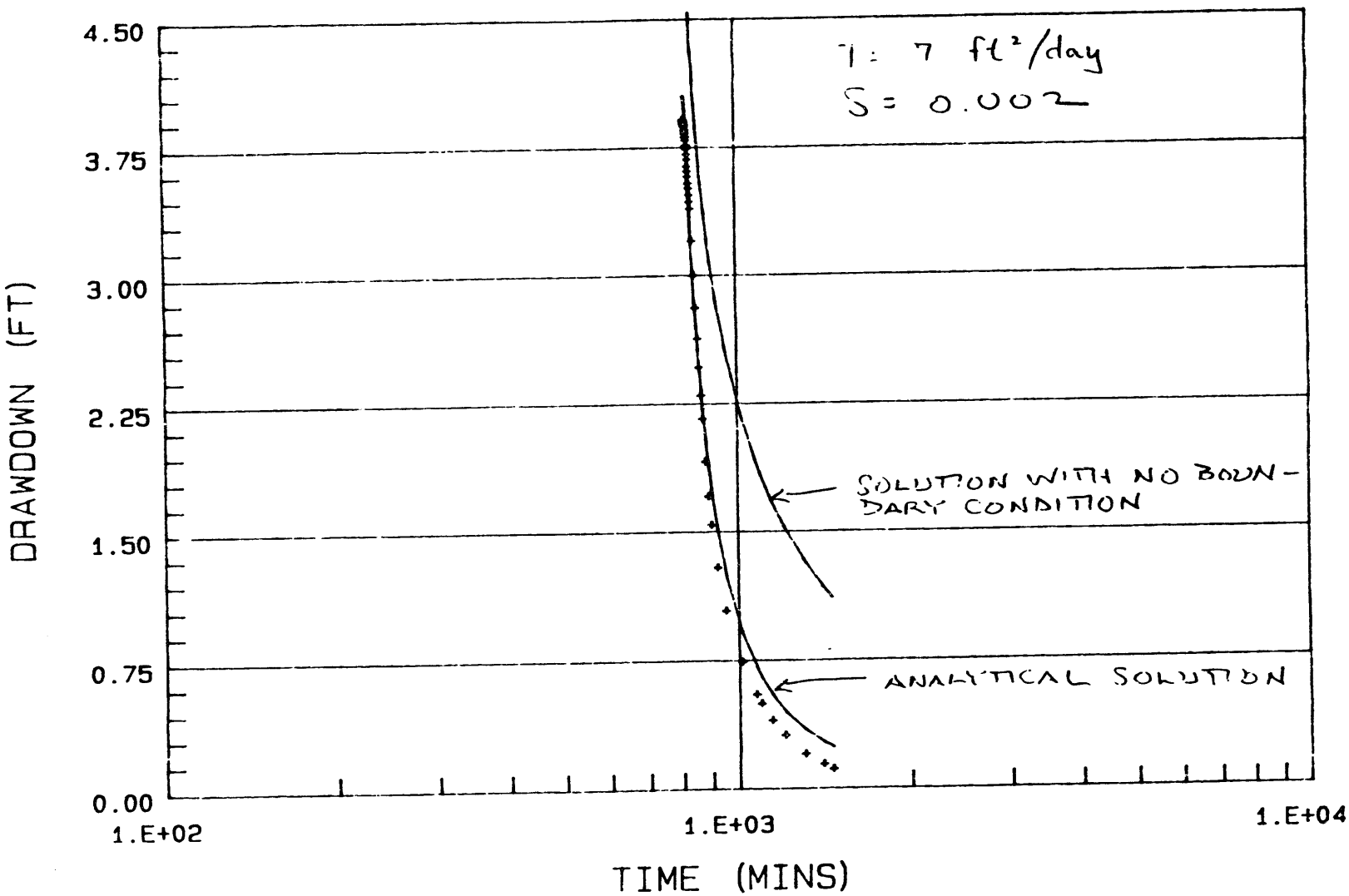
OCT '90

ETM 8/29/91

MONITOR WELL 619, RECH. BOUNDARY



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L.M. COONS PE, PHG

OCT '90

CSD 10/8/91

KHL 10/3/92

ET 8/24/91

BODO CANYON CLIFF HOUSE/MENEFEE AQUIFER TEST, 1989
OBSERVATION WELL 619, PUMPING WELL 617
RECOVERY DATA FOR OBSERVATION WELL 619

Caf 10/2/91
KAL 10/3/91

L.M. COONS PE, PHg

OCT '90 ET 8/29/91

NUMBER	TIME (MINS)	OBSERVED DRAWDOWN (FT)	COMPUTED DRAWDOWN (FT)	DIFFERENCE (FT)
1	814.000	3.910	4.150	-0.240
2	815.000	3.900	4.148	-0.248
3	816.000	3.900	4.111	-0.211
4	817.000	3.890	4.043	-0.153
5	818.000	3.880	3.966	-0.086
6	819.000	3.870	3.888	-0.018
7	820.000	3.850	3.813	0.037
8	821.000	3.830	3.742	0.088
9	822.000	3.810	3.675	0.135
10	823.000	3.790	3.612	0.178
11	824.000	3.760	3.552	0.208
12	825.000	3.740	3.497	0.243
13	826.000	3.710	3.444	0.266
14	827.000	3.680	3.394	0.286
15	828.000	3.640	3.347	0.293
16	829.000	3.610	3.303	0.307
17	830.000	3.580	3.260	0.320
18	831.000	3.540	3.220	0.320
19	832.000	3.510	3.181	0.329
20	833.000	3.470	3.144	0.326
21	834.000	3.430	3.108	0.322
22	835.000	3.390	3.074	0.316
23	840.000	3.200	2.922	0.278
24	845.000	3.000	2.793	0.207
25	850.000	2.810	2.682	0.128
26	855.000	2.630	2.585	0.045
27	860.000	2.460	2.498	-0.038
28	865.000	2.300	2.420	-0.120
29	870.000	2.160	2.349	-0.189
30	880.000	1.910	2.224	-0.314
31	890.000	1.710	2.116	-0.406
32	900.000	1.540	2.025	-0.485
33	920.000	1.290	1.869	-0.579
34	950.000	1.040	1.683	-0.643
35	1010.000	0.740	1.424	-0.684
36	1070.000	0.550	1.244	-0.694
37	1090.000	0.500	1.196	-0.696
38	1140.000	0.400	1.091	-0.691
39	1200.000	0.310	0.989	-0.679
40	1300.000	0.200	0.859	-0.659
41	1400.000	0.140	0.761	-0.621
42	1454.000	0.110	0.717	-0.607

L.M. COONS PE PHg

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

OCT '90

CALCULATION COVER SHEET

CALC NO. DUR03-10-90-15-04-00 DISCIPLINE HYDRO NO. OF SHEETS 19

PROJECT: UMTRA / DOE.

SITE: DUR

FEATURE: Dilution calcs. for steady-state flow through the cell mixing with underflow in uppermost aquifer — BODO CANYON

SOURCES OF DATA: UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:

[illegible]

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st prelim.	Clark Grose	10/3/91	Kenneth Lambert	10/3/90	L Coons	10/90

6/86

DURANGO CALCULATION DUR03-09-90-15-04-00

MIXING OF TAILINGS SEEPAGE WITH GROUNDWATER AT THE BODO CANYON DISPOSAL SITE NEAR DURANGO, COLORADO

1. PURPOSE

The purpose of these mixing and dilution calculations is to estimate the concentrations of hazardous constituents and selected other constituents in groundwater beneath the Bodo Canyon disposal cell for both steady-state and transient fluxes from the disposal cell.

2. METHOD AND PROCEDURES

A simplified solute-balance equation (Hem, 1985) is used to calculate resultant concentrations in groundwater beneath the cell. The equation is as follows:

$$C_1Q_1 + C_2Q_2 - C_3(Q_1+Q_2) = 0$$

Where:

C_1 = concentration of solute before dilution (tailings pore water),

Q_1 = volume rate of flow before dilution (tailings pore water),

C_2 = concentration of solute in diluting water (groundwater underflow), and

Q_2 = volume rate of dilution water,

C_3 = final concentration observed.

3. ASSUMPTIONS

The solute-balance equation is simplified because it assumes complete mixing in the saturated zone.

An inflow-outflow balance is assumed (that is, it is assumed there is no change in storage).

In the analyses, source term strength is the mean or median observed concentration of each hazardous constituent in the tailings pore water sampled from the tailings monitor wells (Table

L.M. COLLIS P.E. PHD
OCT '90

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1). The most conservative case is to use the monitor well mean or median concentration as the input variable (C_1) and mix it with groundwater beneath the disposal cell (C_2); this represents no alteration of the C_1 concentration between the base of the tailings and saturated zone.

Realistically, the monitor well concentrations will decrease by some amount during transport between the tailings and the groundwater. Specifically at the Bodo Canyon disposal site, the tailings leachate will pass through 10 to 65 feet of unsaturated alluvium and weathered shale. Furthermore, these calculations do not take into account the effects of the geochemically reducing environment downgradient of the disposal cell.

These analyses assume that background groundwater quality is the mean or median of all observed concentrations in monitor wells completed in the Cliff House/Menefee aquifer.

The thickness of the mixing zone within the Cliff House/Menefee aquifer underlying the disposal cell is assumed to be 120 feet (Figure 1).

The hydraulic conductivity of the Cliff House/Menefee aquifer is considered to be the geometric mean of all field hydraulic conductivities measured in the Cliff House and Menefee formations.

4. DATA SOURCES

Source term concentrations from Durango calculation DUR03-09-90-15-01-00.

Background groundwater quality of the uppermost aquifer (Cliff House/Menefee aquifer) at the Durango disposal site is from Durango calculation DUR03-09-90-14-10-00.

Aquifer parameters of the Cliff House/Menefee aquifer are from Durango calculations DUR03-09-90-14-03-00 (hydraulic conductivity), and DUR03-09-90-14-18-00 (hydraulic gradient), and DUR03-09-90-14-07-00 (average linear groundwater velocity).

Volume rates of disposal cell drainage are obtained from Durango calculation DUR03-09-90-12-05-00.

Total area of the Durango disposal cell was obtained from Durango calculation DUR03-02-89-13-03-00.

5. CALCULATIONS AND ANALYSES

Equation variables:

TABLE 1.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS , Durango Processing Site, Durango, Colorado
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
15	303.0000	770.0000	590.0000	534.4000	164.6979	0.3082	0.0	422.8149	645.9851	NORMAL	
AMMONIUM			MG/L								
5	0.5000	2.2000	0.5000	1.0800	0.8136	0.7534	0.0	-0.2834	2.4434	NORMAL	
ARSENIC			MG/L								
15	0.0900	0.5700	0.1900	0.2433	0.1386	0.5697	0.0	0.1494	0.3373	NORMAL	
BARIUM			MG/L								
15	0.0200	0.0600	0.0500	NA	NA	NA	66.7	0.0300	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
15	0.0050	0.1600	~~0.0050~~ 0.01	NA	NA	NA	66.7	0.0050	0.1000	NONPARAMETRIC	2
CADMIUM			MG/L								
15	0.0140	0.0630	0.0370	0.0355	0.0155	0.4374	0.0	0.0250	0.0460	NORMAL	
CALCIUM			MG/L								
15	513.0000	609.0000	583.0000	564.1333	35.8725	0.0636	0.0	539.8292	588.4375	NORMAL	
CHEMICAL OXYGEN DEMAND			MG/L								
5	12.0000	52.0000	22.0000	28.4000	15.7734	0.5554	0.0	1.9684	54.8316	NORMAL	
CHLORIDE			MG/L								
15	59.0000	210.0000	75.0000	98.5533	55.6753	0.5649	0.0	60.8325	136.2742	NORMAL	
CHROMIUM			MG/L								
15	0.0050	0.2600	~~0.0050~~ 0.01 a	NA	NA	NA	66.7	0.0050	0.1800	NONPARAMETRIC	2
COBALT			MG/L								
5	0.0700	0.2000	0.1100	0.1280	0.0492	0.3843	0.0	0.0456	0.2104	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

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a DART DIVIDES DETECTION LIMIT BY TWO THEREFORE MULTIPLY BY 2 TO GET CORRECT MEAN OR MEDIAN.

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OCT '90

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COPPER	MG/L	15	0.0300	0.0600	0.0400	0.0447	0.0106	0.2373	0.0	0.0375	0.0518	NORMAL	
CYANIDE	MG/L	10	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
FLUORIDE	MG/L	15	0.4000	1.6000	0.6000	0.7333	0.4012	0.5471	0.0	0.4615	1.0051	NORMAL	
GROSS ALPHA	PCI/L	15	820.0000	14200.0000	2900.0000	4288.0000	3983.8804	0.9291	0.0	1588.8658	6987.1342	NORMAL	
GROSS BETA	PCI/L	15	330.0000	4300.0000	780.0000	1340.0000	1246.8131	0.9305	0.0	495.2668	2184.7332	NORMAL	
IRON	MG/L	15	0.0900	0.6300	0.1400	0.2140	0.1722	0.8047	0.0	0.0973	0.3307	NORMAL	
LEAD	MG/L	15	0.0050	0.0200	~~0.0050~~ 0.01	NA	NA	NA	53.3	0.0050	0.0200	NONPARAMETRIC	2
MAGNESIUM	MG/L	15	41.2000	166.0000	68.5000	79.2133	42.2838	0.5338	0.0	50.5655	107.8612	NORMAL	
MANGANESE	MG/L	15	3.0300	8.6300	6.0100	5.6407	1.4050	0.2491	0.0	4.6888	6.5925	NORMAL	
MERCURY	MG/L	15	0.0001	0.0004	0.0001	NA	NA	NA	66.7	0.0001	0.0003	NONPARAMETRIC	2
MOLYBDENUM	MG/L	15	0.8100	3.9800	1.7300	1.9460	1.0904	0.5603	0.0	1.2073	2.6847	NORMAL	

NET GROSS ALPHA = -795

Alpha activity due to uranium

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCi

L.M. COOKS P.E., PHE
OCT '90

D. Cat. 10/3 KRL 10/3/9

T-1 cont.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
				UNITS								
NICKEL				MG/L								
	5	0.0200	0.0700	0.0400	NA	NA	NA	40.0	0.0200	0.0700	NONPARAMETRIC	2,5
NITRATE				MG/L								
	15	0.5000	22.0000	1.6000	NA	NA	NA	40.0	0.5000	4.5000	NONPARAMETRIC	2
POTASSIUM				MG/L								
	15	12.6000	30.6000	17.2000	19.8467	6.4953	0.3273	0.0	15.4460	24.2473	NORMAL	
RADIUM-226				PCI/L								
	15	5.9000	18.0000	9.9000	10.5067	3.3484	0.3187	0.0	8.2380	12.7753	NORMAL	
RADIUM-228				PCI/L								
	15	0.0000	0.8000	0.3000	NA	NA	NA	26.7	0.0000	0.7000	NONPARAMETRIC	2
SELENIUM				MG/L								
	15	0.0450	0.4080	0.1320	0.1745	0.1237	0.7091	0.0	0.0906	0.2583	NORMAL	
SILVER				MG/L								
	15	0.0050	0.0700	~~0.0050~~ 0.012	NA	NA	NA	53.3	0.0050	0.0400	NONPARAMETRIC	2
SODIUM				MG/L								
	15	122.0000	727.0000	228.0000	371.9333	248.5048	0.6681	0.0	203.5679	540.2988	NORMAL	
SPECIFIC CONDUCTANCE				UMHO/CM								
	15	1850.0000	3800.0000	2100.0000	2576.6667	755.4248	0.2932	0.0	2064.8559	3088.4775	NORMAL	
SULFATE				MG/L								
	15	1540.0000	2800.0000	1710.0000	2029.3333	482.1302	0.2376	0.0	1702.6834	2355.9832	NORMAL	

ADD

* Statistical maximum is the 99 percent one sided confidence interval, α = 0.01
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

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OCT '90

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFIDE	MG/L	5	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,5
TEMPERATURE	C - DEGREE	15	9.0000	15.0000	11.5000	11.5000	1.8127	0.1576	0.0	10.2719	12.7281	NORMAL	
THALLIUM	MG/L	15	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
TIN	MG/L	5	0.0025	0.0025	0.0025	NA	NA	NA	100.0	0.0025	0.0025	NONPARAMETRIC	2,5
TOTAL DISSOLVED SOLIDS	MG/L	15	2790.0000	5080.0000	3250.0000	3710.0000	910.0628	0.2453	0.0	3093.4198	4326.5802	NORMAL	
TOTAL ORGANIC CARBON	MG/L	5	116.0000	169.0000	125.0000	137.2000	23.7634	0.1732	0.0	97.3794	177.0206	NORMAL	
URANIUM	MG/L	15	1.4700	21.6000	4.5400	7.4120	6.8766	0.9278	0.0	2.7530	12.0710	NORMAL	
VANADIUM	MG/L	5	5.7000	14.4000	11.1000	10.4720	3.9374	0.3760	0.0	3.8741	17.0699	NORMAL	
ZINC	MG/L	15	0.1920	4.7900	2.0200	2.1270	1.5515	0.7294	0.0	1.0758	3.1782	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

INPUT DATA FILENAME: J:\DART\DUR03\GWQ10006.DAT

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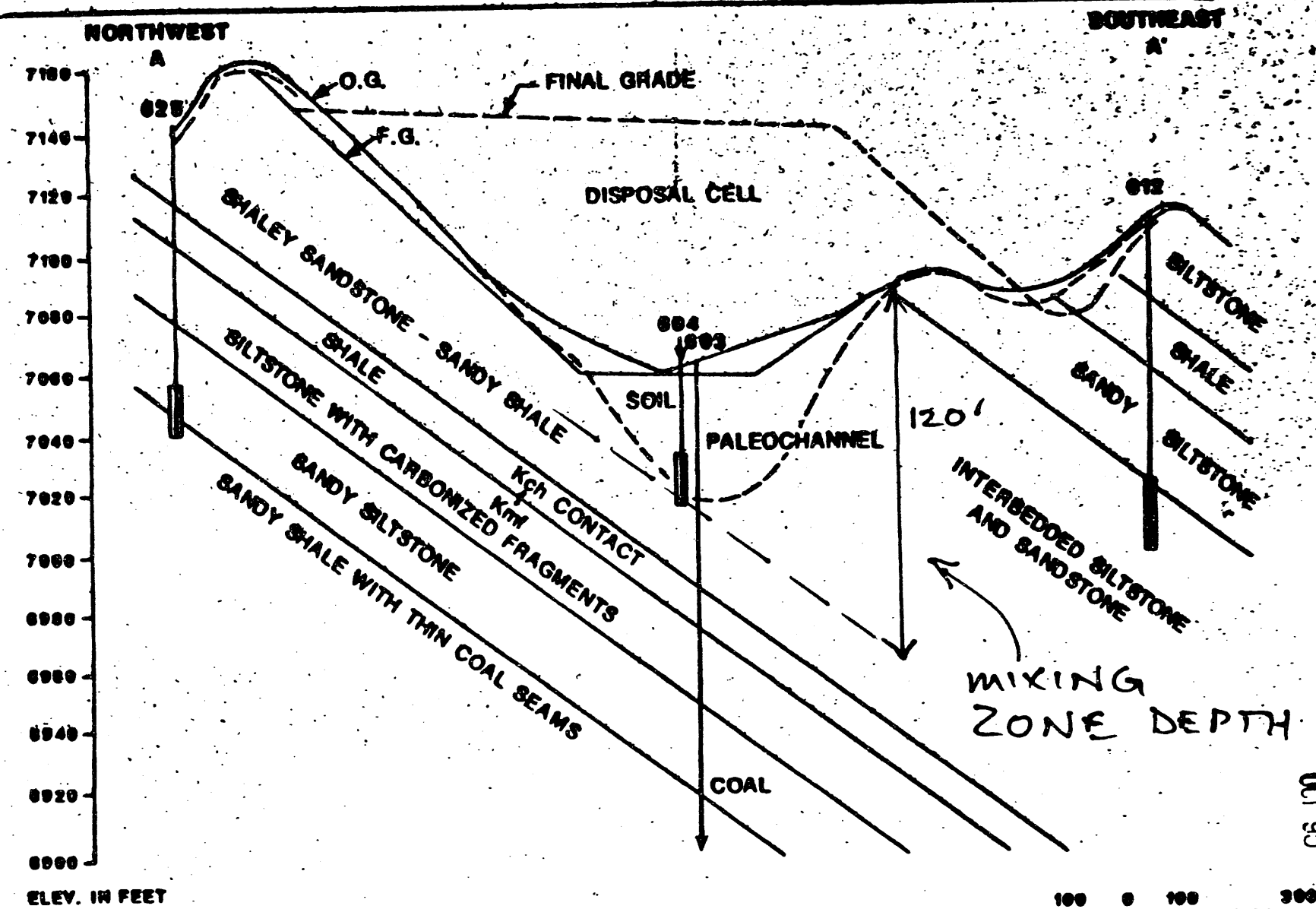

NOTE: APPARENT DIP ALONG SECTION IS APPROXIMATELY 6.5 DEGREES (TRUE DIP IS ABOUT 9.5 DEGREES)

O.G. - ORIGINAL GRADE
Kch - CLIFFHOUSE SANDSTONE
Kmf - MENEFEE FORMATION

FIGURE ~~3~~ 1

CROSS SECTION A-A' THROUGH CENTER OF DISPOSAL CELL AND MIXING ZONE
BODO CANYON SITE, COLORADO

L.M. COONS P.E. PHR 10/3/90

OCT '90

LM. COOKS PC. FILE
OCT '90

9/17 MFI, Cop 10/3/90 KAL 10/3/90

C_1 = constant, see tailings pore water quality statistics by parameter in Table 1.

Q_1 = variable, transient drainage rate (most conservative) will be used.

C_2 = constant, see background groundwater quality statistics by parameter at the Bodo Canyon disposal site in Table 3.

Q_2 = constant, see Q_2 determination below.

C_3 = variable - resultant concentration.

The simplified solute-balance equation is modified to separate out the C_3 term. Therefore:

$$C_3 = \frac{C_1Q_1 + C_2Q_2}{Q_1 + Q_2}$$

Determination of Q_1

The area of the disposal cell is 1.4×10^6 square feet. The volume flow rate for transient drainage (Q_1) for the scarified clay liner flux of 1.6×10^{-8} $cm^3/cm^2/sec$ is 3.15×10^{-8} feet/min., therefore:

$$Q_1 = (3.15 \times 10^{-8} \text{ feet/min.})(1.4 \times 10^6 \text{ feet}^2)(7.48 \text{ gals/ft}^3)$$

$$Q_1 = 0.33 \text{ gallons per minute.}$$

Determination of Q_2

The volume flow rate (Q_2) beneath the disposal cell is calculated to be:

$$Q_2 = L * t * K * dh/dl$$

where:

L = Length of disposal cell perpendicular to groundwater flow direction in feet (Figure 2),

t = thickness of unsaturated material in feet,

K = hydraulic conductivity in feet/day, and

dh/dl = hydraulic gradient, dimensionless.

TABLE 3

GROUNDWATER QUALITY STATISTICS BY PARAMETER
DISPOSAL SITE BEDROCK MONITOR WELLS, Durango, Colorado
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	34	96.0000	1449.0000	715.0000	744.2647	300.2123	0.4034	0.0	618.4330	870.0964	NORMAL	
AMMONIUM	MG/L	10	1.2000	6.2000	2.0500	2.6500	1.8265	0.6892	0.0	1.0206	4.2794	NORMAL	
ANTIMONY	MG/L	18	0.0015	0.0270	0.0023	NA	NA	NA	50.0	0.0015	0.0170	NONPARAMETRIC	2
ARSENIC	MG/L	34	0.0050	0.0240	~~0.0050~~ 0.01 a	NA	NA	NA	76.5	0.0050	0.0050	NONPARAMETRIC	2
BARIUM	MG/L	30	0.0100	0.3000	0.0500	NA	NA	NA	80.0	0.0500	0.0500	NONPARAMETRIC	2
BERYLLIUM	MG/L	21	0.0050	0.0050	~~0.0050~~ 0.01 a	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
CADMIUM	MG/L	34	0.0005	0.0190	~~0.0005~~ 0.001 a	NA	NA	NA	67.6	0.0005	0.0010	NONPARAMETRIC	2
CALCIUM	MG/L	34	2.3700	466.0000	146.0000	152.2882	136.6270	0.8972	0.0	95.0220	209.5544	NORMAL	
CHEMICAL OXYGEN DEMAND	MG/L	3	8.0000	52.0000	12.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE	MG/L	33	8.0000	428.0000	37.0000	39.7269	1.9538	NA	0.0	29.8628	52.8492	LOGNORMAL	7,8

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

a - Don't divides detection limit by two before printing Sta by parameter, therefore multiply by two to get correct

L.M. COONS PE, PHG
OCT '90
10/3/90
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T. 15 3 cont.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
DISPOSAL SITE BEDROCK MONITOR WELLS
SITE: DUR03 DODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 07/06/90

PARAMETER NAME / # OF SAMP	MINIMUM	MAXIMUM	UNITS / MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM			MG/L								
30	0.0050	0.1200	~~0.0050~~ 0.01 a	NA	NA	NA	73.3	0.0050	0.0050	NONPARAMETRIC	2
COBALT			MG/L								
21	0.0250	0.0250	~~0.0250~~ 0.05 a	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2
COPPER			MG/L								
30	0.0100	0.0300	~~0.0100~~ 0.02 a	NA	NA	NA	90.0	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE			MG/L								
19	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
FLUORIDE			MG/L								
29	0.2000	3.7500	0.3100	0.6136	2.8208	NA	0.0	0.3816	0.9868	LOGNORMAL	7,8
GROSS ALPHA			PCI/L								
29	0.0000	38.0000	4.0000	NA	NA	NA	31.0	0.0000	14.0000	NONPARAMETRIC	2
GROSS BETA			PCI/L								
29	6.6000	40.0000	17.0000	19.2034	10.0228	0.5219	0.0	14.6119	23.7950	NORMAL	
IRON			MG/L								
34	0.0150	231.0000	0.3700	0.5973	6.9965	NA	2.9	0.2643	1.3499	LOGNORMAL	7,8
LEAD			MG/L								
30	0.0050	0.0200	~~0.0050~~ 0.01 a	NA	NA	NA	83.3	0.0050	0.0050	NONPARAMETRIC	2
MAGNESIUM			MG/L								
34	0.2400	455.0000	122.5000	30.3747	9.8949	NA	0.0	11.6223	79.3837	LOGNORMAL	7,8

NET GROSS ALPHA = 1.9

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

NET GROSS ALPHA = (GROSS ALPHA − URANIUM) WITH 1 MG URANIUM = 686 PCi

L.M. COONS P.E., PHE
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
DISPOSAL SITE BEDROCK MONITOR WELLS
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE	MG/L	34	0.0050	5.0000	0.0650	0.0759	4.5738	NA	5.9	0.0401	0.1435	LOGNORMAL	7,8
MERCURY	MG/L	34	0.0001	0.0004	0.0001	NA	NA	NA	88.2	0.0001	0.0001	NONPARAMETRIC	2
MOLYBDENUM	MG/L	34	0.0050	0.2200	0.0075	NA	NA	NA	50.0	0.0050	0.0660	NONPARAMETRIC	2
NICKEL	MG/L	21	0.0200	0.0700	0.0200	NA	NA	NA	90.5	0.0200	0.0200	NONPARAMETRIC	2
NITRATE	MG/L	28	0.5000	10.0000	~~0.5000~~ 1.0 a	NA	NA	NA	60.7	0.5000	1.6000	NONPARAMETRIC	2
NITRITE AND NITRATE	MG/L	7	0.5000	0.5000	0.5000	NA	NA	NA	100.0	0.5000	0.5000	NONPARAMETRIC	2
POTASSIUM	MG/L	34	5.3000	39.8000	7.3500	11.9474	9.7578	0.8167	0.0	7.8574	16.8373	NORMAL	
RADIUM-226	PCI/L	33	0.0000	3.4000	0.1000	NA	NA	NA	15.2	0.1000	0.3000	NONPARAMETRIC	2
RADIUM-228	PCI/L	33	0.0000	5.8000	0.1000	NA	NA	NA	48.5	0.0000	0.6000	NONPARAMETRIC	2
SELENIUM	MG/L	34	0.0010	0.0420	~~0.0025~~ .0005 a	NA	NA	NA	50.0	0.0025	0.0180	NONPARAMETRIC	2

USED DETECT LIMIT (0.01) WHICH IS > MEDIAN (MORE CONSERVATIVE)

ADD

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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T. [illegible] v 3 cont.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
DISPOSAL SITE BEDROCK MONITOR WELLS
SITE: DUR03 DODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SILVER			MG/L								
34	0.0050	0.0380	~~0.0050~~ 0.01	NA	NA	NA	94.1	0.0050	0.0050	NONPARAMETRIC	2
SODIUM			MG/L								
34	164.0000	682.0000	307.5000	383.2941	168.1114	0.4386	0.0	312.8315	453.7567	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
34	335.0000	3350.0000	1783.0000	1803.6471	557.7890	0.3093	0.0	1569.8539	2037.4402	NORMAL	
SULFATE			MG/L								
33	97.0000	3910.0000	834.0000	991.7576	873.0960	0.8804	0.0	619.6946	1363.8205	NORMAL	
SULFIDE			MG/L								
20	0.0500	42.2000	1.2000	NA	NA	NA	40.0	0.0500	7.8000	NONPARAMETRIC	2
TEMPERATURE			C - DEGREE								
34	10.0000	13.0000	11.1000	11.2559	0.9404	0.0835	0.0	10.8617	11.6500	NORMAL	
THALLIUM			MG/L								
21	0.0050	0.0100	0.0050	NA	NA	NA	95.2	0.0050	0.0050	NONPARAMETRIC	2
THORIUM-230			PCI/L								
4	0.0000	0.3000	0.1000	NA	NA	NA	25.0	0.0000	0.3000	NONPARAMETRIC	2,4
TIN			MG/L								
21	0.0025	0.0510	0.0025	NA	NA	NA	57.1	0.0025	0.0220	NONPARAMETRIC	2
TOTAL DISSOLVED SOLIDS			MG/L								
33	750.0000	5480.0000	1980.0000	2302.0000	1126.3837	0.4893	0.0	1822.0005	2781.9995	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

L.M. COUNS [illegible], PHD
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
DISPOSAL SITE BEDROCK MONITOR WELLS
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
URANIUM			MG/L								
31	0.0003	0.0282	0.0015	NA	NA	NA	22.6	0.0012	0.0036	NONPARAMETRIC	2
VANADIUM			MG/L								
21	0.0050	0.0600	0.0200	NA	NA	NA	33.3	0.0050	0.0200	NONPARAMETRIC	2
ZINC			MG/L								
30	0.0025	0.0164	0.0125	NA	NA	NA	36.7	0.0025	0.0160	NONPARAMETRIC	2

0.003 a

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: J:\DART\DUR03\GW010007.DAT

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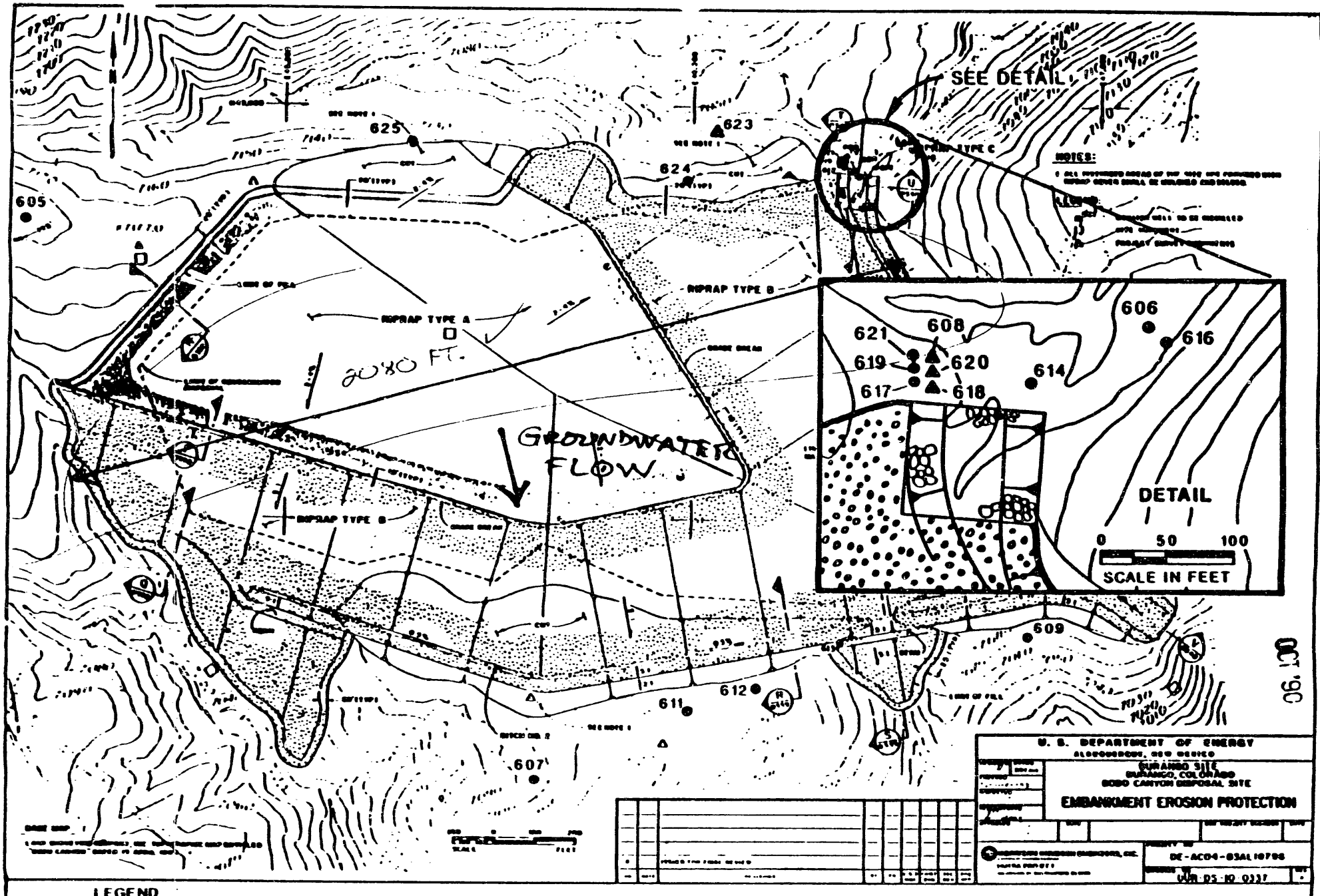
Cap 10/3/90
KAC 10/3/90



LEGEND

● BEDROCK MONITOR WELL

▲ ALLUVIAL MONITOR WELL

FIGURE # 2

WELL LOCATIONS, BODO CANYON DISPOSAL SITE

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15/17 cop 10/3/90

KAL 10/3/90

E.M. COOKS PE. PHB
OCT '90

cap 10/8/9
KAL 10/3/9

therefore, for an aquifer thickness of 120 feet,

$$Q_2 = 2080 \text{ feet} * 120 \text{ feet} * 0.07 \text{ ft/day} * 0.19 \text{ feet/day} = 3,319.7 \text{ ft}^3/\text{day}$$

$$Q_2 = 17.2 \text{ gpm.}$$

SOLUTION

The final concentrations (C_3) for all of the hazardous constituents are shown in Table 4.

CONCLUSIONS AND RECOMMENDATIONS

The hazardous constituents with EPA MCLs that have been determined to be of concern at the Bodo Canyon disposal site are arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, combined radium-226 and -228, selenium, silver, uranium. In addition to these hazardous constituents, ~~six~~ Six other constituents without EPA MCLs are of concern. These are antimony, beryllium, cobalt, copper, nickel, vanadium, and zinc.

The concentration, C_3, in the ~~uppermost~~ aquifer beneath the Bodo Canyon disposal site of these ~~18~~ 20 hazardous constituents and constituents of concern have been calculated using the simplified solute-balance equation. In solving for C_3, the flux of the scarified clay liner was used for transient conditions which is the most conservative case. The source concentrations (C_1), the background concentrations (C_2), and the mixing and dilution resultant concentrations (C_3) are presented in Table 3. The resultant concentrations will be used as the estimated concentrations at the Bodo Canyon Disposal site point of compliance.

All of the resulting concentrations are below proposed concentration limits for the point of compliance except those of uranium and vanadium.

REFERENCES

Hem. J.D., 1985, Study and interpretation of the chemical characteristics of natural waters, U.S. Geological Survey, 263 pp.

L.M. COONS PE, PHD 17/17 ~~[illegible]~~ Cap

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DATE 10/3/90 BY Cap CHKD.

SUBJECT TABLE 4 RESULTS OF SATURATED ZONE MIXING AND DILUTION CALCULATIONS

SHEET NO. KAL

JOB NO. 10/3/9

	MEAN OR MEDIAN SOURCE CONCENTRATION	MEAN OR MEDIAN BACKGROUND	FINAL CONCENTRATION (C_3)
ARSENIC	0.243 ✓	0.01 ✓	0.015 ✓ (0.014)
CADMIUM	0.037 ✓	0.001 ✓	0.002 ✓
CHROMIUM	0.01 ✓	0.01 ✓	0.01 ✓
LEAD	0.01 ✓	0.01 ✓	0.01 ✓
MOLYBDENUM	1.95 ✓	0.01 ✓	0.05 ✓
NITRATE	1.6 ✓	1.0 ✓	1.[illegible] ✓
RADIUM 226+/228	10.2 pCi/L ✓	0.2 pCi/L ✓	0.43 pCi/L ✓ (0.39)
SELENIUM	0.175 ✓	0.005 ✓	[illegible] ✓ (0.008)
SILVER	0.01 ✓	0.01 ✓	[illegible] ✓
URANIUM	7.41 ✓	0.003 ✓	[illegible] ✓ (0.14)
BERYLLIUM	0.01 ✓	0.01 ✓	[illegible] ✓
COBALT	0.128 ✓	0.05 ✓	[illegible] ✓
COPPER	0.045 ✓	0.02 ✓	[illegible] ✓
VANADIUM	10.50 ✓	0.02 ✓	[illegible] ✓
ZINC	2.13 ✓	0.013 ✓	[illegible] ✓ (0.05)

$Q_1 = 0.33$ gpm $Q_2 = 17.2$ gpm

(rounding error does not impact results)

FORM 91-005-1 (4/81)

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CALCULATION COVER SHEET

CALC NO. DUR03-10-90-14-07-00 DISCIPLINE HYDRO NO. OF SHEETS 4 5

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO DISPOSAL SITE

FEATURE:
AVERAGE LINEAR GROUNDWATER VELOCITIES FOR ALLUVIUM AND FOR CLIFF HOUSE/MENEFEE

SOURCES OF DATA:
DURANGO CALCS. FOR AQUIFER PROPERTIES

SOURCES OF FORMULAE & REFERENCES:
FREEZE, R.A., CHERRY, J.A., 1979, GROUNDWATER, PRENTICE HALL, NEW JERSEY, 604 pp.

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1ST PRELIM.	[illegible]	10/3/90	Kevin A Lambert	10/3/90	L Coons	10/90
01	CHANGED DUE TO REVISED ALLUVIUM K	[illegible]	8/17/91	E Todd Monke	8/29/91		

B/86

Caf
8/17
E TW
8/29/9

DURANGO CALCULATION DUR03-10-90-14-07-00

AVERAGE LINEAR GROUNDWATER VELOCITY IN ALLUVIUM AND IN CLIFF HOUSE/MENEFEE AQUIFER

BODO CANYON DISPOSAL SITE

PURPOSE

The purpose of this calculation is to determine the average linear groundwater velocity for the alluvium and for the Cliff House/Menefee aquifer at the Bodo Canyon disposal site. These velocities will be reported in Attachment 3 of the Durango R.A.S.

PROCEDURE

The linear groundwater velocity is the rate at which the groundwater moves through the pore spaces. Where,

$$V_L = \frac{K\ i}{n}$$

K = hydraulic conductivity

i = hydraulic gradient

n = effective porosity

V_L = linear groundwater velocity

ASSUMPTIONS

It is assumed that the hydraulic conductivities, hydraulic gradients, and porosities used in the calculations are representative of the actual aquifer properties.

PROPERTIES

The hydraulic conductivity for the alluvium used in these calculations is the geometric mean of all lab and field data. This hydraulic conductivity is 0.13 ft/day.

The hydraulic conductivity for the Cliff House/Menefee aquifer used in these calculations is the geometric mean of all field data. This hydraulic conductivity is 0.07 ft/day.

The hydraulic gradient for the alluvium used in these calculations is from Durango calculation DUR03-09-90-14-06-00. This hydraulic gradient is 0.003.

CAJ 9/12/9
ETM 9/12/9

The hydraulic gradient for the Cliff House/Menefee aquifer used in these calculations is from Durango calculation DUR03-09-90-14-06-00. This hydraulic gradient is 0.19.

The effective porosities used in these calculations are estimated from ranges of literature values of similar geohydraulic units present at Bodo Canyon. A porosity at the lower end of the range for sand and silt (see attachment) was chosen for the alluvium to yield the highest (most conservative) velocity estimate of groundwater flow. For the Cliff House/Menefee aquifer, a porosity less than the average value of the range for sandstone (see attachment) was chosen since it is know that this formation is weathered near the contact with the alluvium.

DATA SOURCES

Hydraulic conductivities for the Cliff House/Menefee aquifer and for the alluvium: Durango calculation DUR03-10-90-15-04-00.

Hydraulic gradients: Durango calculation DUR03-09-90-14-06-00.

Effective porosities: Groundwater, by Freeze and Cherry, 1979.

SOLUTION

ALLUVIUM: $V_L = \frac{ki}{n} = \frac{(0.13)(0.003)}{0.25} = 0.002$ FT/DAY
0.7 FT/YR.

CLIFF HOUSE/MENEFEE: $V_L = \frac{ki}{n} = \frac{(0.07)(0.19)}{0.15} = 0.09$ FT/DAY
32 FT/YR.

CONCLUSIONS AND RECOMMENDATIONS

The calculated average linear groundwater velocity for the alluvium is 0.002 ft/day (0.7 ft/year).

The calculated average linear groundwater velocity for the Cliff House/Menefee aquifer is 0.09 ft/day (32 ft/year).

These values will be reported in the Durango R.A.S. as part of the hydraulic characterization of these two units.

Ca
9/12
ETL
9/12

REFERENCES

Freeze, R. A., and Cherry, J. A., 1979, Groundwater, Prentice Hall, New Jersey, 604 pp.

ATTACHMENT

Table 2.4, page 37 "Range of Values of Porosity" from Groundwater (Freeze and Cherry, 1979).

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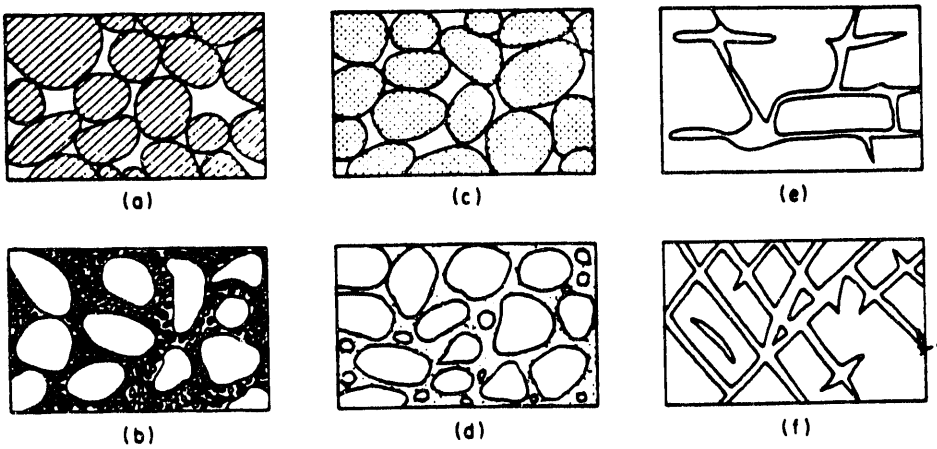

Figure 2.11 Relation between texture and porosity. (a) Well-sorted sedimentary deposit having high porosity; (b) poorly sorted sedimentary deposit having low porosity; (c) well-sorted sedimentary deposit consisting of pebbles that are themselves porous, so that the deposit as a whole has a very high porosity; (d) well-sorted sedimentary deposit whose porosity has been diminished by the deposition of mineral matter in the interstices; (e) rock rendered porous by solution; (f) rock rendered porous by fracturing (after Meinzer, 1923).

soil or rock matrix [Figure 2.11(a), (b), (c), and (d)], and *secondary porosity*, which may be due to such phenomena as secondary solution [Figure 2.11(e)] or structurally controlled regional fracturing [Figure 2.11(f)].

Table 2.4, based in part on data summarized by Davis (1969), lists representative porosity ranges for various geologic materials. In general, rocks have lower porosities than soils; gravels, sands, and silts, which are made up of angular and

Table 2.4 Range of Values of Porosity

	n(%)
Unconsolidated deposits	
Gravel	25–40
Sand	25–50
Silt	35–50
Clay	40–70
Rocks	
Fractured basalt	5–50
Karst limestone	5–50
Sandstone	5–30
Limestone, dolomite	0–20
Shale	0–10
Fractured crystalline rock	0–10
Dense crystalline rock	0–5

ESTIMATED ALLUVIUM ϕ 0.25

ESTIMATED CLIFF HOUSE/MENEFEE ϕ 0.15

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OCT '90

CALCULATION COVER SHEET

CALC NO. DUR03-10-90-12-05-00 DISCIPLINE HYDRO NO. OF SHEETS 3

PROJECT:
UMTRA SITE CHARACTERIZATION

SITE:
DURANGO DISPOSAL SITE

FEATURE:
(1) TRANSIENT SEEPAGE RATE FROM DISPOSAL CELL
(2) TRANSIENT AND STEADY-STATE SEEPAGE IN 1 CM² DURING 1000 YRS.

SOURCES OF DATA:
DURANGO ENGINEERING CALC.
DURANGO ENGINEERING CALC.
DURANGO CALC. DUR-02-89-13-03a-00

SOURCES OF FORMULAE & REFERENCES:
NO REFS.

PRELIMINARY CALC. ☐ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00	1st PRELIM.	Clark Fore	10/3/90	Karen Hamlet	10/3/90	J. Corne	10/90

W/85

L.M. COONS ... 10/3/9

OCT '90

KAL 10/3/90

DURANGO CALCULATION DUR03-10-90-12-05-00

TRANSIENT AND STEADY-STATE SEEPAGE THROUGH 1 CM^2 FOR 1000 YEARS

PURPOSE

The purpose of this calculation is to determine the volume of seepage that will exit the disposal cell over a 1000 year period in 1 cm^2. This total volume is a combination of transient drainage for approximately 200 years and steady-state drainage for the next 800 years (Engineering Calculation DUR-09-90-12-01-00). The area of 1 cm^2 was selected as a convenient unit for the calculations. The resultant water volume from this calculation is used in a geochemistry calculation to determine the attenuation capacity of the sub-disposal cell sediments for vanadium.

PROCEDURE

The volume of water/cm^2 during transient drainage is determined by multiplying the transient drainage rate (in $cm^3/cm^2/sec$) by 200 years (in seconds). This will yield cm^3 of water/cm^2 in 200 years. Then, the volume of water/cm^2 during steady-state drainage is determined by multiplying the steady-state drainage rate (in $cm^3/cm^2/sec$) by 800 years (in seconds). This will yield cm^3 of water/cm^2 in 800 years. The two volumes are then added together to yield cm^3 of water/cm^2 in 1000 years.

ASSUMPTIONS

$K'_{sat} = 1.6 \times 10^{-8}$ cm/sec ; flux = K x unit gradient

It is assumed that 1.6×10^{-8} $cm^3/cm^2/sec$ is an accurate representation of the vertical ~~permeability of~~ flux of tailings fluids through the scarified clay liner.

It is assumed that the prediction of lengths of time for transient and steady-state drainage is accurate.

DATA SOURCES

The permeability of the scarified clay liner is from Durango engineering calculation DUR-01-90-02-01-00.

The lengths of time for transient and steady-state drainage is from Durango engineering calculation DUR-09-90-12-01-00

The steady-state drainage rate is from Durango calculation Dur-02-89-13-03a-00.

SOLUTION

(TRANSIENT RATE)(200 YRS.) = vol. water / 200 YRS.

$(1.6 \times 10^{-8}\ cm^3/cm^2/s)(6.31 \times 10^9\ sec) = 100.9\ cm^3/cm^2/200\ YRS$

(STEADY-STATE RATE)(800 YRS.) = Vol. water / 800 YRS.

M. COOK PHB OCT '90 KAL 10/3/9

$(5 \times 10^{-9}\ cm^3/cm^2/sec)(2.52 \times 10^{10}\ sec) = 126.1\ cm^3/cm^2/800\ YRS.$

$100.9 \times 126.1 = 227\ cm^3/cm^2/1000\ YRS.$

$227\ cm^3 = 0.227\ L = \boxed{0.23\ L}$

RESULTS AND CONCLUSIONS

The result of the above calculation is that 0.23 L of water/cm^2 will exit the base of the disposal cell over a 1000 year period. This value is used in the Durango geochemistry calculation DUR-01-90-13 (K-06)

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CALCULATION COVER SHEET

CALC NO. DUR-09-90-~~07~~-14(01)-00 DISCIPLINE Geochemistry NO. OF SHEETS 61

PROJECT: UMTRA

SITE: Durango 03 - Bodo Canyon Disposal Cell

FEATURE: Estimation of Point of Compliance Concentrations

SOURCES OF DATA:
Analytical data - UMTRA DART system
Thermodynamic data - PHRTHERM.DAT Data base of 09/15/90.

SOURCES OF FORMULAE & REFERENCES:
Parkhurst et al; 1980; PHREEQE; U.S. Geol. Survey Water Resources Invest. 80-96.

PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		W. F. Downs	9/27/90	[illegible]	10/1/90	[illegible]	10/2/90

M/SS

CALC. SET: DUR-09-90-~~01~~ 14-14-00

L.M. COONS PE. PHG OCT '90

10/1/90

A. Purpose of Calculation

This calculation set is designed to mathematically simulate the following activities:

a. Mixing the tailings pore fluid (2.5 %) with the native groundwater (97.5 %) of the Cliff House/Menefee aquifer.

b. Equilibration of the above mixture in the geochemical environment native to the Cliff House/Menefee aquifer to determine which mineral phases would become supersaturated.

c. Equilibration of the above mixture with the mineral phases that were indicated as supersaturated in step b to determine the equilibrium concentration of hazardous constituents in the groundwater-tailings fluid mixture in the environment of the Cliff House-Menefee aquifer.

B. Method and Procedures

Analytical data were retrieved from the DART system and these were used as input to the PHREEQE geochemical simulator code. The analytical data were collected during regular sampling rounds at the Bodo Canyon site. All analytical data were collected in accordance with UMTRA Standard Operating Procedures and met UMTRA Quality Standards.

C. ASSUMPTIONS

1. The fluid samples from the 200 series monitor wells are true representations of the tailings pore fluids. valid for

2. The fluid samples from MW-605 is a true representative of the background groundwaters in the Cliff House-Menefee aquifer. valid for

3. The geochemical environment measured in MWs 607~~, 611 and 612~~ is representative of that of the Cliff House-Menefee aquifer. valid for

4. The system will, in time (<1,000 yrs), come to equilibrium. valid for

5. Data for all species and components that are important in this groundwater system are contained within the thermodynamic data base. valid for

D. MATERIAL PROPERTIES

Attachment A is a listing of the mean concentrations of major, minor and trace constituents for the tailings monitoring wells and the Cliff House-Menefee background monitoring well (MW-605). The only other data used in this simulation is the reducing Eh measured in MW-607: -0.028 mV. This measurement was collected by W. F. Downs on 06/18/90.

E. DATA SOURCES

The thermodynamic data are contained within the data base that is attached to the PHREEQE code.

L.M. COOMS PE, PHG

OCT '90

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10/1/90

F. CALCULATION AND ANALYSIS

All calculations are conducted by the code using matrix algebra algorithms. A full explanation of the method is contained within Parkhurst et al.; 1980; PHREEQE - A COMPUTER PROGRAM FOR GEOCHEMICAL CALCULATIONS; U.S. Geol. Survey Water Resour. Invest. 80-96, 210 p. Attachment B is the computer printout for all of the simulations in this calculation set.

G. CONCLUSIONS

The conclusions and recommendations from this calculation set are contained within the Durango Remedial Action Selection Report and it's attendant attachments. In summary, the solubility of uraninite (UO_2) will control the equilibrium concentration of uranium. This equilibrium concentration will be below the maximum concentration limit specified in the UMTRA groundwater standards.

H. RESULTS

See Attachment B-3 and "G" above

I. REFERENCES: See the cover sheet and "F" above of this calculation.

J. ATTACHMENTS

A : Major, minor and trace constituents for the tailings monitoring wells and the Cliff House - Menefee background monitoring well (MW-

B-1 : Results of Mixing various portions of Tailings Pore Fluid with Cliff House Background Groundwater data from well #MW-605

B-2 : Results of Equilibration of the Tailing Pore Fluid - Cliff House Background Groundwater. Mixture with the Geochemical Environment of the Cliff House - Menefee Aquifer

B-3 : Equilibration of the mixed water in B-2 with Uraninite and Goethite and determination of the Residual Uranium Concentration

TABLE 4.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUROC BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY			MG/L CACO3								
15	303.0000	770.0000	590.0000	534.4000	164.6979	0.3082	0.0	422.8149	645.9851	NORMAL	
AMMONIUM			MG/L								
5	0.5000	2.2000	0.5000	1.0800	0.8136	0.7534	0.0	-0.2834	2.4434	NORMAL	
ARSENIC			MG/L	0.459							
15	0.0900	0.5700	0.1900	0.2433	0.1386	0.5697	0.0	0.1496	0.3373	NORMAL	
BARIUM			MG/L								
15	0.0200	0.0600	0.0500	NA	NA	NA	66.7	0.0300	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
15	0.0050	0.1600	0.0050	NA	NA	NA	66.7	0.0050	0.1000	NONPARAMETRIC	2
CADMIUM			MG/L								
15	0.0140	0.0630	0.0370	0.0355	0.0155	0.4374	0.0	0.0250	0.0460	NORMAL	
CALCIUM			MG/L								
15	513.0000	609.0000	583.0000	564.1333	35.8725	0.0636	0.0	539.8292	588.4375	NORMAL	
CHEMICAL OXYGEN DEMAND			MG/L								
5	12.0000	52.0000	22.0000	28.4000	15.7734	0.5554	0.0	1.9684	54.8316	NORMAL	
CHLORIDE			MG/L								
15	59.0000	210.0000	75.0000	98.5533	55.6753	0.5649	0.0	60.8325	136.2742	NORMAL	
CHROMIUM			MG/L								
15	0.0050	0.2600	0.0050	NA	NA	NA	66.7	0.0050	0.1800	NONPARAMETRIC	2
COBALT			MG/L								
5	0.0700	0.2000	0.1100	0.1280	0.0492	0.3843	0.0	0.0456	0.2104	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

Data (9 pages)

L.M. COORS PE. PMS

OCT '90

10/11

T. 4.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COPPER			MG/L								
15	0.0300	0.0600	0.0400	0.0447	0.0106	0.2373	0.0	0.0375	0.0518	NORMAL	
CYANIDE			MG/L								
10	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
FLUORIDE			MG/L								
15	0.4000	1.6000	0.6000	0.7333	0.4012	0.5471	0.0	0.4615	1.0051	NORMAL	
GROSS ALPHA			PCI/L								
15	820.0000	14200.0000	2900.0000	4288.0000	3983.8804	0.9291	0.0	1588.8658	6987.1342	NORMAL	
GROSS BETA			PCI/L								
15	330.0000	4300.0000	780.0000	1340.0000	1246.8131	0.9305	0.0	495.2668	2184.7332	NORMAL	
IRON			MG/L								
15	0.0900	0.6300	0.1400	0.2140	0.1722	0.8047	0.0	0.0973	0.3307	NORMAL	
LEAD			MG/L								
15	0.0050	0.0200	0.0050	NA	NA	NA	53.3	0.0050	0.0200	NONPARAMETRIC	2
MAGNESIUM			MG/L								
15	41.2000	166.0000	68.5000	79.2133	42.2838	0.5338	0.0	50.5655	107.8612	NORMAL	
MANGANESE			MG/L								
15	3.0300	8.6300	6.0100	5.6407	1.4050	0.2491	0.0	4.6888	6.5925	NORMAL	
MERCURY			MG/L								
15	0.0001	0.0004	0.0001	NA	NA	NA	66.7	0.0001	0.0003	NONPARAMETRIC	2
MOLYBDENUM			MG/L	3.26							
15	0.8100	3.9800	1.7300	1.9460	1.0904	0.5603	0.0	1.2073	2.6847	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

L.M. COOMS PE, PHE
OCT '90

A-2

T. 1.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NICKEL	MG/L	5	0.0200	0.0700	0.0400	NA	NA	NA	40.0	0.0200	0.0700	NONPARAMETRIC	2,5
NITRATE	MG/L	15	0.5000	22.0000	1.6000	NA	NA	NA	40.0	0.5000	4.5000	NONPARAMETRIC	2
POTASSIUM	MG/L	15	12.6000	30.6000	17.2000	19.8467	6.4953	0.3273	0.0	15.4460	24.2473	NORMAL	
RADIUM-226	PCI/L	15	5.9000	18.0000	9.9000	10.5067	3.3484	0.3187	0.0	8.2380	12.7753	NORMAL	
RADIUM-228	PCI/L	15	0.0000	0.8000	0.3000	NA	NA	NA	26.7	0.0000	0.7000	NONPARAMETRIC	2
SELENIUM	MG/L	15	0.0450	0.4080	0.1320	0.1745	0.1237	0.7091	0.0	0.0906	0.2583	NORMAL	
SILVER	MG/L	15	0.0050	0.0700	0.0050	NA	NA	NA	53.3	0.0050	0.0400	NONPARAMETRIC	2
SODIUM	MG/L	15	122.0000	727.0000	228.0000	371.9333	248.5048	0.6681	0.0	203.5679	540.2988	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	15	1850.0000	3800.0000	2100.0000	2576.6667	755.4248	0.2932	0.0	2064.8559	3088.4775	NORMAL	
SULFATE	MG/L	15	1540.0000	2800.0000	1710.0000	2029.3333	482.1302	0.2376	0.0	1702.6834	2355.9832	NORMAL	

5.0

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

L.M. COGGINS
OCT '90

10/1/90

T. 4.

GROUNDWATER QUALITY STATISTICS BY PARAMETER
TAILINGS MONITOR WELLS
SITE: DUR03 BODO CANYON
12/01/88 TO 04/05/89
REPORT DATE: 07/06/90

PARAMETER NAME			UNITS					STATISTICAL RANGE			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFIDE			MG/L								
5	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,5
TEMPERATURE			C - DEGREE								
15	9.0000	15.0000	11.5000	11.5000	1.8127	0.1576	0.0	10.2719	12.7281	NORMAL	
THALLIUM			MG/L								
15	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
TIN			MG/L								
5	0.0025	0.0025	0.0025	NA	NA	NA	100.0	0.0025	0.0025	NONPARAMETRIC	2,5
TOTAL DISSOLVED SOLIDS			MG/L								
15	2790.0000	5080.0000	3250.0000	3710.0000	910.0628	0.2453	0.0	3093.4198	4326.5802	NORMAL	
TOTAL ORGANIC CARBON			MG/L								
5	116.0000	169.0000	125.0000	137.2000	23.7634	0.1732	0.0	97.3794	177.0206	NORMAL	
URANIUM			MG/L	8.37							
15	1.4700	21.6000	4.5400	7.4120	6.8766	0.9278	0.0	2.7530	12.0710	NORMAL	
VANADIUM			MG/L								
5	5.7000	14.4000	11.1000	10.4720	3.9374	0.3760	0.0	3.8741	17.0699	NORMAL	
ZINC			MG/L								
15	0.1920	4.7900	2.0200	2.1270	1.5515	0.7294	0.0	1.0758	3.1782	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.

INPUT DATA FILENAME: J:\DART\DUR03\GWQ10006.DAT

L.M. COOKS PE, PMB
OCT '90

10/11/90

4-4

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BODO CANYON MW-605: BACKGROUND IN CLIFF HOUSE FM.
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 08/30/90

PARAMETER NAME			UNITS		STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL		DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN				MINIMUM	MAXIMUM *		
ALKALINITY			MG/L CACO3								
9	664.0000	757.0000	721.0000	719.3333	33.5410	0.0466	0.0	686.9551	751.7116	NORMAL	
AMMONIUM			MG/L								
2	2.5000	2.8000	2.6500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY			MG/L								
3	0.0015	0.0090	0.0030	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
ARSENIC			MG/L								
9	0.0050	0.0200	0.0050	NA	NA	NA	66.7	0.0050	0.0200	NONPARAMETRIC	2
BARIUM			MG/L								
7	0.0300	0.0500	0.0500	NA	NA	NA	85.7	0.0300	0.0500	NONPARAMETRIC	2
BERYLLIUM			MG/L								
4	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,4
CADMIUM			MG/L								
9	0.0005	0.0070	0.0005	NA	NA	NA	66.7	0.0005	0.0070	NONPARAMETRIC	2
CALCIUM			MG/L								
9	143.0000	169.0000	149.0000	151.7778	8.8569	0.0584	0.0	143.2279	160.3276	NORMAL	
CHEMICAL OXYGEN DEMAND			MG/L								
1	8.0000	8.0000	8.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE			MG/L								
9	32.0000	40.0000	35.0000	35.8333	2.5739	0.0718	0.0	33.3487	38.3180	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

L.M. COGGINS PE, PHG
OCT '90
10/1/90

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BODO CANYON MW-605: BACKGROUND IN CLIFF HOUSE FM.
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 08/30/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM	MG/L	7	0.0050	0.0700	0.0050	NA	NA	NA	71.4	0.0050	0.0700	NONPARAMETRIC	2
COBALT	MG/L	4	0.0250	0.0250	0.0250	NA	NA	NA	100.0	0.0250	0.0250	NONPARAMETRIC	2,4
COPPER	MG/L	7	0.0100	0.0100	0.0100	NA	NA	NA	85.7	0.0100	0.0100	NONPARAMETRIC	2
CYANIDE	MG/L	4	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,4
FLUORIDE	MG/L	7	0.2000	0.3200	0.3000	0.2743	0.0513	0.1869	0.0	0.2134	0.3352	NORMAL	
GROSS ALPHA	PCI/L	7	0.0000	6.3000	0.0000	NA	NA	NA	57.1	0.0000	6.3000	NONPARAMETRIC	2
GROSS BETA	PCI/L	7	6.7000	20.0000	11.0000	11.3429	4.5709	0.4030	0.0	5.9129	16.7728	NORMAL	
IRON	MG/L	9	0.1200	1.1200	0.6800	0.6189	0.3440	0.5559	0.0	0.2868	0.9510	NORMAL	
LEAD	MG/L	7	0.0050	0.0200	0.0050	NA	NA	NA	85.7	0.0050	0.0200	NONPARAMETRIC	2
MAGNESIUM	MG/L	9	114.0000	148.0000	126.0000	128.8889	11.0617	0.0858	0.0	118.2107	139.5671	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

T.H 6.8.-
E/1

L.M. COCHRANE, PHG
OCT '90
10/1/90

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BODO CANYON MW-605: BACKGROUND IN CLIFF HOUSE FM.
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 08/30/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE	MG/L	9	0.0400	0.1500	0.0600	0.0678	0.0327	0.4825	0.0	0.0362	0.0993	NORMAL	
MERCURY	MG/L	9	0.0001	0.0002	0.0001	NA	NA	NA	88.9	0.0001	0.0002	NONPARAMETRIC	2
MOLYBDENUM	MG/L	9	0.0050	0.0900	0.0050	NA	NA	NA	55.6	0.0050	0.0900	NONPARAMETRIC	2
NICKEL	MG/L	4	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,4
NITRATE	MG/L	7	0.5000	5.3000	1.1000	NA	NA	NA	42.9	0.5000	5.3000	NONPARAMETRIC	2
NITRITE AND NITRATE	MG/L	1	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
POTASSIUM	MG/L	9	6.6000	9.2700	7.1000	7.4100	0.8047	0.1086	0.0	6.6332	8.1868	NORMAL	
RADIUM-226	PCI/L	9	0.0000	0.2000	0.1000	NA	NA	NA	33.3	0.0000	0.2000	NONPARAMETRIC	2
RADIUM-228	PCI/L	9	0.0000	2.5000	0.0000	NA	NA	NA	55.6	0.0000	2.5000	NONPARAMETRIC	2
SELENIUM	MG/L	9	0.0010	0.0420	0.0080	0.0144	0.0132	0.9154	11.1	0.0017	0.0271	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

L.M. COCKS PE, PHR
OCT '90
10/1/90

GROUNDWATER QUALITY STATISTICS BY PARAMETER
RODO CANYON MW-605: BACKGROUND IN CLIFF HOUSE FM.
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 08/30/90

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SILVER	MG/L	9	0.0050	0.0200	0.0050	NA	NA	NA	88.9	0.0050	0.0200	NONPARAMETRIC	2
SODIUM	MG/L	9	273.0000	353.0000	312.0000	312.0000	23.3399	0.0748	0.0	289.4692	334.5308	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	9	1400.0000	2005.0000	1780.0000	1734.1111	182.1829	0.1051	0.0	1558.2439	1909.9783	NORMAL	
SULFATE	MG/L	9	757.0000	938.0000	834.0000	850.0000	62.1731	0.0731	0.0	789.9822	910.0178	NORMAL	
SULFIDE	MG/L	4	0.0500	0.2000	0.1150	NA	NA	NA	50.0	0.0500	0.2000	NONPARAMETRIC	2,4
TEMPERATURE	C - DEGREE	9	10.0000	12.0000	11.3000	11.1667	0.6205	0.0556	0.0	10.5677	11.7656	NORMAL	
THALLIUM	MG/L	4	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,4
THORIUM-230	PCI/L	2	0.0000	0.3000	0.1500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TIN	MG/L	4	0.0025	0.0070	0.0037	NA	NA	NA	50.0	0.0025	0.0070	NONPARAMETRIC	2,4
TOTAL DISSOLVED SOLIDS	MG/L	9	1740.0000	3550.0000	1980.0000	2133.3333	546.3515	0.2561	0.0	1605.9220	2660.7447	NORMAL	

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.

L.M. COOKS P.E. PHB
OCT '90
10/1/90

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BODO CANYON MW-605: BACKGROUND IN CLIFF HOUSE FM.
SITE: DUR03 BODO CANYON
09/13/87 TO 05/11/90
REPORT DATE: 08/30/90

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
URANIUM			MG/L								
9	0.0006	0.0015	0.0015	NA	NA	NA	66.7	0.0006	0.0015	NONPARAMETRIC	2
VANADIUM			MG/L								
4	0.0100	0.0200	0.0150	0.0150	0.0058	0.3849	0.0	0.0019	0.0281	NORMAL	
ZINC			MG/L								
7	0.0025	0.0130	0.0025	NA	NA	NA	57.1	0.0025	0.0130	NONPARAMETRIC	2

* Statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.

INPUT DATA FILENAME: J:\DART\DUR03\GWQ10026.DAT

L.M. COCHS PE, PHG
OCT '90

10/1/90

6-9

Attachment B-1 V

L.M. COCKS P.E., PHD

OCT '90

32 continuous pages

M. Thompson

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DATA READ FROM DISK

ELEMENTS
SPECIES
LOOK MIN
MIXING CALCULATION OF BODO CANYON TAILINGS PORE FLUIDS WITH CLIFF HOUSE BKGRND
DD1D111000 5 0          .00000
ELEMENTS
C         10          50.
           0           0.
SOLUTION 1
DURANGO TAILING PORE FLUIDS (MEAN OF MONITOR WELLS 200 - 204)
16 10 2    6.60      6.73      11.5      1.00
   6  4.590D-01  12  3.500D-02  11  5.641D+02  13  9.860D+01  10  5.340D+02
  16  7.300D-01  17  2.100D-01  21  7.920D+01  22  5.640D+00  35  3.260D+00
  23  5.000D+00  34  2.130D+00  19  1.985D+01  24  3.720D+02  29  2.029D+03
  32  8.370D+00
STEPS
  .100E-01  .200E-01  .250E-01  .300E-01  .500E-01
SOLUTION NUMBER 1          DURANGO TAILING PORE FLUIDS (MEAN OF MONITOR WELLS 200 - 204)
```

NB: Dilution 3 is used as input for calcs in Att's B-2 & B-3.

10/1/90

(All B-1 pages were checked J.D.)

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AG	3.2457730-06	-5.4887
TOT AL	1.0710750-02	-1.9700
CA	1.4126940-02	-1.8500
CD	3.1058310-07	-6.5051
CL	2.7910390-03	-2.5540
F	3.8540780-03	-4.4178
FE	3.7747140-06	-5.4231
K	5.2950750-04	-3.2959
MG	3.0690330-03	-2.4888
NA	1.0330480-02	-1.9860
P	8.2960290-05	-4.0918
SR	1.8241550-03	-2.7394
S	2.1000790-02	-1.6776
U	3.1112670-05	-4.5071
ZN	3.2705550-05	-4.4854
MO	2.0459110-05	-4.6891

----DESCRIPTION OF SOLUTION----

```
                 PH =   6.6000
                 PE =   6.7281
       ACTIVITY H2O =   .9999
      IONIC STRENGTH =   .0497
         TEMPERATURE =  11.5000
ELECTRICAL BALANCE =  -4.0000E-07
                MUE =  1.8748E-01
      TOTAL ALKALINITY =  1.0000E-01
           ITERATIONS =  14
      TOTAL DEPTH =  1.6070E-01
```

[illegible]

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	3.114220-07	-6.5067	2.511890-07	-6.6000	8.065850-01	-.0933
2	E-	-1.0	1.870250-07	-6.7281	1.870250-07	-6.7281	1.000000+00	.0000
3	H20	.0	9.988430-01	-.0005	9.988430-01	-.0005	1.000000+00	.0000
6	H3AS04	.0	4.406550-11	-10.3559	4.476420-11	-10.3491	1.015860+00	.0068
10	C03 2-	-2.0	2.593090-06	-5.5862	1.097530-06	-5.9596	4.232530-01	-.3734
11	CA 2+	2.0	9.192420-03	-2.0366	4.256310-03	-2.3710	4.630240-01	-.3344
12	CD 2+	2.0	1.315800-07	-6.8808	5.569160-08	-7.2542	4.232530-01	-.3734
13	CL-	-1.0	2.[illegible]91160-03	-2.5542	2.201780-03	-2.6572	7.888420-01	-.1030
16	F-	-1.0	3.582920-05	-4.4458	2.889930-05	-4.5391	8.065850-01	-.0933
17	FE 2+	2.0	1.577370-06	-5.8021	6.676260-07	-6.1755	4.232530-01	-.3734
19	K+	1.0	4.933610-04	-3.3068	3.891840-04	-3.4098	7.888420-01	-.1030
21	MG 2+	2.0	2.169390-03	-2.6639	1.031860-03	-2.9864	4.758640-01	-.3225
22	MN 2+	2.0	7.098630-05	-4.1488	3.004520-05	-4.5222	4.232530-01	-.3734
23	N03 -	-1.0	1.309960-10	-9.8827	1.056600-10	-9.9761	8.065850-01	-.0933
24	NA+	1.0	1.575770-02	-1.8025	1.274100-02	-1.8948	8.085540-01	-.0923
29	S04 2-	-2.0	1.507490-02	-1.8217	6.107470-03	-2.2141	4.051430-01	-.3924
32	U02 2+	2.0	1.722220-10	-9.7639	7.289360-11	-10.1373	4.232530-01	-.3734
34	ZN 2+	2.0	1.918000-05	-4.7172	8.118010-06	-5.0906	4.232530-01	-.3734
35	M004 2-	-2.0	2.045910-05	-4.6891	8.659360-06	-5.0635	4.232530-01	-.3734
51	H3AS03	.0	2.992740-17	-16.5242	3.036160-17	-16.5174	1.015860-00	.0068
53	FE 3+	3.0	1.030780-12	-11.9868	1.489420-13	-12.8270	1.444940-01	-.8401
54	MN 3+	3.0	4.401070-24	-23.3564	6.359050-25	-24.1966	1.444940-01	-.8401
55	NH4 +	1.0	7.470520-05	-4.1266	6.035610-05	-4.2200	8.065850-01	-.0933
56	N02 -	-1.0	3.570590-07	-6.4473	2.879990-07	-6.5406	8.065850-01	-.0933
61	U02 +	1.0	1.341690-14	-13.8723	1.082190-14	-13.9657	8.065850-01	-.0933
65	O++	-1.0	1.701960-08	-7.7690	1.372780-08	-7.8624	8.065850-01	-.0933
75	NH4SO4 -	-1.0	5.877670-06	-5.2305	4.740840-06	-5.3241	8.065850-01	-.0933
76	MSO- +	1.0	2.449670-09	-8.6109	1.975870-09	-8.7042	8.065850-01	-.0933
77	MGF +	1.0	1.680070-06	-5.7746	1.355080-06	-5.8680	8.065850-01	-.0933
78	M3U02 4+	7.0	8.647430-07	-6.0631	8.764570-07	-6.0567	1.015860+00	.0068
79	MG-U02 +	1.0	1.105770-04	-3.9485	9.079900-05	-4.0419	8.065850-01	-.0933
80	MGSO4 AQ	.0	9.863980-04	-3.0060	1.001960-03	-2.9992	1.015860-00	.0068
84	CAOH +	1.0	1.654310-09	-8.7814	1.334340-09	-8.8747	8.065850-01	-.0933
85	CA-U02 +	1.0	2.943090-04	-3.5310	2.373950-04	-3.6243	8.065850-01	-.0933
86	CA02 AQ	.0	5.144000-06	-5.2887	5.205560-06	-5.2819	1.015860-00	.0068
87	CASO4 AQ	.0	4.874070-03	-2.3120	4.707990-03	-2.3320	1.015860-00	.0068
91	CAF +	1.0	9.800420-07	-6.0089	7.904870-07	-6.1021	8.065850-01	-.0933
92	NA02 -	-1.0	1.574730-07	-6.8028	1.270150-07	-6.8961	8.065850-01	-.0933
93	NA-U02 AQ	.0	4.157070-05	-4.3817	4.222980-05	-4.3744	1.015860-00	.0068
94	NASO4 -	-1.0	4.420590-04	-3.3545	3.565560-04	-3.4479	8.065850-01	-.0933
96	NAF AQ	.0	5.678380-08	-7.2307	5.971580-08	-7.2239	1.015860-00	.0068
97	KSO4 -	-1.0	1.618010-05	-4.7910	1.305220-05	-4.8843	8.065850-01	-.0933
109	FEO- +	1.0	3.618760-10	-9.4414	2.918830-10	-9.5348	8.065850-01	-.0933
110	FEOH2 -1	-1.0	4.603530-19	-18.3369	3.713140-19	-18.4303	8.065850-01	-.0933
111	FESO4 AQ	.0	5.511660-07	-6.2587	5.599050-07	-6.2519	1.015860+00	.0068
113	FEO-2 AQ	.0	2.640660-15	-14.5463	2.887730-15	-14.5394	1.015860-00	.0068
117	FEO- 2+	2.0	3.930280-09	-8.4056	1.663500-09	-8.7790	4.232530-01	-.3734
119	FESO4 +	1.0	6.859730-12	-11.1637	5.532950-12	-11.2570	8.065850-01	-.0933
120	FEO2 2+	2.0	1.496590-14	-13.8255	6.326910-15	-14.1989	4.232530-01	-.3734
121	FEO2 +	1.0	1.207580-16	-15.9181	9.740120-17	-16.0114	8.065850-01	-.0933
122	FEO2 AQ	.0	2.111390-20	-19.6755	2.144560-20	-19.6687	1.015860-00	.0068
123	FEO-2 +	1.0	1.617530-06	-5.7921	1.301770-06	-5.8855	8.065850-01	-.0933
124	FEO-2 AQ	.0	2.657500-08	-7.5775	2.709600-08	-7.5671	1.015860-00	.0068
125	FEO-3 -	-1.0	8.601660-10	-9.0651	6.978150-10	-9.1588	8.065850-01	-.0933
126	FEO-3 2-	2.0	1.296670-11	-10.8873	5.487550-12	-11.2609	4.232530-01	-.3734
128	FEO +	1.0	6.676670-12	-11.1757	5.344610-12	-11.2691	8.065850-01	-.0933
129	FEO2 AQ	.0	2.397000-17	-16.6249	2.372440-17	-16.6251	1.015860-00	.0068
130	FEO-2 +	1.0	1.285770-11	-11.8918	1.036150-11	-11.9851	8.065850-01	-.0933
131	FEO-3 -	-1.0	4.160390-15	-14.3807	1.375750-14	-13.8613	3.309370-02	-1.4804
132	FEO-3 2-	2.0	2.807[illegible]-17	-16.5647	[illegible]	[illegible]	[illegible]	[illegible]

138	MNCL3 -	-1.0	1.96992D-13	-12.7056	1.58891D-13	-12.7989	8.06585D-01	-.0933
139	MNOH +	1.0	1.20250D-09	-8.9199	9.69920D-10	-9.0133	8.06585D-01	-.0933
140	MN(OH)3	-1.0	3.71208D-20	-19.4304	2.99411D-20	-19.5237	8.06585D-01	-.0933
141	MNF +	1.0	7.62100D-09	-8.1180	6.14698D-09	-8.2113	8.06585D-01	-.0933
142	MNSO4 AQ	.0	2.76294D-05	-4.5586	2.80674D-05	-4.5518	1.01586D+00	.0068
143	MN(NO3)2	.0	1.35683D-24	-23.8675	1.37834D-24	-23.8606	1.01586D+00	.0068
144	MNHCO3 +	1.0	4.08830D-06	-5.3885	3.29756D-06	-5.4818	8.06585D-01	-.0933
162	ZNCL +	1.0	3.19727D-08	-7.4952	2.57867D-08	-7.5886	8.06585D-01	-.0933
163	ZNCL2 AQ	.0	5.52957D-11	-10.2573	5.61724D-11	-10.2505	1.01586D+00	.0068
164	ZNCL3 -	-1.0	1.58052D-13	-12.8012	1.27482D-13	-12.8945	8.06585D-01	-.0933
165	ZNCL4 2-	-2.0	2.96454D-16	-15.5280	1.25475D-16	-15.9014	4.23253D-01	-.3734
166	ZNF +	1.0	3.43966D-09	-8.4635	2.77438D-09	-8.5568	8.06585D-01	-.0933
167	ZNOH +	1.0	1.43392D-08	-7.8435	1.15657D-08	-7.9368	8.06585D-01	-.0933
168	ZN(OH)2	.0	3.01693D-10	-9.5204	3.06476D-10	-9.5136	1.01586D+00	.0068
169	ZN(OH)3	-1.0	2.61974D-15	-14.6162	1.95172D-15	-14.7096	8.06585D-01	-.0933
170	ZN(OH)4	-2.0	9.17792D-22	-21.0373	3.88458D-22	-21.4107	4.23253D-01	-.3734
171	ZNOHCL A	.0	2.31680D-09	-8.6351	2.35[illegible]D-09	-8.6283	1.01586D+00	.0068
174	ZNSO4 AQ	.0	1.02613D-05	-4.9888	1.04240D-05	-4.9820	1.01586D+00	.0068
175	ZN(SO4)2	-2.0	1.36324D-06	-5.8654	5.76995D-07	-6.2388	4.23253D-01	-.3734
180	ZNHCO3 +	1.0	3.49314D-16	-15.4568	2.81752D-16	-15.5501	8.06585D-01	-.0933
181	ZNCO3 AQ	.0	1.74999D-06	-5.7570	1.77773D-06	-5.7501	1.01586D+00	.0068
182	ZN(CO3)2	-2.0	9.85562D-08	-7.0063	4.17142D-08	-7.3797	4.23253D-01	-.3734
183	CDCL +	1.0	1.38486D-08	-7.8586	1.11701D-08	-7.9519	8.06585D-01	-.0933
184	CDCL2 AQ	.0	9.58082D-11	-10.0186	9.73273D-11	-10.0118	1.01586D+00	.0068
185	CDCL3 -	-1.0	1.35174D-13	-12.8691	1.09029D-13	-12.9625	8.06585D-01	-.0933
186	CDF +	1.0	2.51200D-11	-10.6000	2.02618D-11	-10.6933	8.06585D-01	-.0933
187	CDF2 AQ	.0	1.44786D-15	-14.8393	1.47084D-15	-14.8324	1.01586D+00	.0068
188	CD(CO3)3	-4.0	3.67751D-18	-17.4194	1.22192D-18	-18.9130	3.20923D-00	-1.4936
189	CDOH +	1.0	8.03307D-12	-11.0947	6.45516D-12	-11.1901	8.06585D-01	-.0933
190	CD(OH)2	.0	3.57215D-15	-14.4470	3.93364D-15	-14.4050	1.01586D+00	.0068
191	CD(OH)3	-1.0	2.17587D-21	-20.6620	1.75500D-21	-20.7587	8.06585D-01	-.0933
192	CD(OH)4	-2.0	1.46954D-28	-27.8328	6.21966D-29	-29.2060	4.23253D-01	-.3734
193	CD2(OH)3	+3.0	1.45331D-17	-16.8372	2.09994D-18	-17.6778	1.44494D-01	-.8401
194	CDCHCL A	.0	1.33611D-11	-10.8740	1.35730D-11	-10.8673	1.01586D+00	.0068
195	CDNO3 +	1.0	2.77011D-17	-16.5570	2.03594D-17	-16.6503	8.06585D-01	-.0933
196	CDSO4 AQ	.0	8.85[illegible]D-08	-7.0527	8.99720D-08	-7.0458	1.01586D+00	.0068
197	CDHCO3 +	1.0	4.78[illegible]D-08	-7.3274	3.85662D-08	-7.4208	8.06585D-01	-.0933
198	CDCO3 AQ	.0	1.57791D-08	-7.8016	1.53180D-08	-7.8149	1.01586D+00	.0068
199	CD(CO3)2	-2.0	1.55208D-08	-7.8081	6.56900D-09	-8.1825	4.23253D-01	-.3734
200	H4SIO4 +	-1.0	5.04131D-22	-19.2974	4.03026D-22	-19.3774	8.06585D-01	-.0933
201	H4SIO4 2-	-2.0	1.77776D-25	-24.7476	7.22814D-26	-25.1410	4.23253D-01	-.3734
202	H4SIO4 +	1.0	4.48770D-24	-23.3480	3.78177D-24	-23.4207	8.06585D-01	-.0933
203	H3SIO4 -	-1.0	1.44553D-06	-5.8401	1.14[illegible]D-06	-5.9333	8.06585D-01	-.0933
204	H2SIO4 2-	-2.0	1.80116D-06	-5.7447	7.61[illegible]D-07	-6.1181	4.23253D-01	-.3734
205	H6SI2O7 -3	-3.0	3.75704D-11	-10.4250	5.42871D-12	-11.2653	1.44494D-01	-.8401
206	HCO3 -	-1.0	1.00883D-02	-1.9960	8.13703D-03	-2.0895	8.06585D-01	-.0933
207	H2CO3 AQ	.0	5.64821D-03	-2.2481	5.73776D-03	-2.2413	1.01586D+00	.0068
208	HSO4 -	-1.0	1.28027D-07	-6.8937	1.03[illegible]D-07	-6.9860	8.06585D-01	-.0933
209	HF AQ	.0	7.99428D-09	-8.0970	8.1[illegible]D-09	-8.0904	1.01586D+00	.0068
210	HFO -	-1.0	1.03810D-12	-11.9840	8.17[illegible]D-13	-12.0874	8.06585D-01	-.0933
211	HFO AQ	.0	3.04048D-16	-15.5171	3.08[illegible]D-16	-15.5103	1.01586D+00	.0068
212	UO2OH +	2.0	1.27765D-29	-28.8936	5.40770D-30	-29.2670	4.23253D-01	-.3734
213	UO2(OH)2	1.0	3.89050D-26	-25.4100	3.13500D-26	-25.5033	8.06585D-01	-.0933
214	UO2(OH)4	.0	2.83661D-23	-22.5472	2.88158D-23	-22.5404	1.01586D+00	.0068
215	UO2F5 -	-1.0	2.70784D-21	-20.5674	3.16470D-21	-20.6607	8.06585D-01	-.0933
216	[illegible]	-1.0	1.26944D-09	-8.8974	1.04204D-09	-8.9907	8.06585D-01	-.0933
217	[illegible]	0.0	1.95[illegible]D-17	-16.7079	8.33[illegible]D-18	-17.0797	4.23253D-01	-.3734
218	[illegible]	1.0	1.67[illegible]D-14	-13.7857	1.32[illegible]D-14	-13.8790	8.06585D-01	-.0933
219	[illegible]	0.0	5.37[illegible]D-17	-16.0716	9.68[illegible]D-17	-16.0179	1.01586D+00	.0068
220	[illegible]	-2.0	1.95[illegible]D-25	-24.8177	6.55[illegible]D-26	-25.1813	4.23253D-01	-.3734
221	[illegible]	-4.0	1.48[illegible]D-17	-16.8377	4.71[illegible]D-17	-16.9310	7.25[illegible]D-02	-1.1397
222	[illegible]	-1.0	3.44[illegible]D-12	-11.4630	2.78[illegible]D-12	-11.5563	8.06585D-01	-.0933
223	[illegible]	0.0	5.35[illegible]D-11	-10.2711	5.44[illegible]D-11	-10.2644	1.01586D+00	.0068
224	[illegible]	-1.0	5.35[illegible]D-17	-16.2718	2.78[illegible]D-17	-16.7551	8.06585D-01	-.0933

312	U02S04 A	.0	1.64379D-10	-9.7842	1.66985D-10	-9.7773	1.01586D+00	.0068
313	U02S04)2	-2.0	6.76454D-11	-10.1698	2.86311D-11	-10.5432	4.23253D-01	-.3734

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-23.5935	-14.4692	-9.1243
U02 (AM	-23.5935	-8.5650	-15.0285
U409 (C)	-67.7183	-41.5185	-26.1999
U308 (C)	-17.4691	-6.0975	-11.3717
UF4 (C)	-68.1490	-28.3599	-39.7891
UF4.2.5H	-68.1502	-37.9663	-30.1839
U03 (C)	3.0622	8.3916	-5.3294
GUMMITE	3.0622	11.1999	-8.1377
B-U02(OH	3.0617	6.0173	-2.9556
SCHOEPIT	3.0612	5.8189	-2.7577
RUTHERFO	-16.0969	-14.4462	-1.6507
ANHYDRIT	-4.5851	-4.5089	-.0762
ARAGONIT	-8.3305	-8.2222	-.1084
ARTINITE	1.2651	10.5991	-9.3339
BRUCITE	10.2126	17.6882	-7.4756
CALCITE	-8.3305	-8.4108	.0802
DOLOMITE	-17.2765	-16.7118	-.5647
EPSOMITE	-5.2240	-2.2350	-2.9660
FERRIHYD	20.3511	18.2676	2.0835
FE3(OH)8	47.7258	46.9852	.7405
FEO-OH.7	17.5741	10.3376	7.2365
FES PRT	-115.0124	-39.6708	-75.3416
FE2(SO4)	-5.5371	32.3904	-37.9275
FLUORITE	-11.4490	-11.1037	-.3255
GOETHITE	20.3516	14.3810	5.9707
GREIGITE	-440.4179	-161.2771	-279.1408
GYPSUM	-4.5841	-4.8570	.2729
HALITE	-4.5500	1.5480	-6.1000
HEMATITE	40.7038	23.8276	16.8761
HUNTITE	-35.1684	-29.0745	-6.0939
HYDEMAGN	-25.5733	-6.9551	-18.6182
JAROSITE	30.2261	29.9600	.2661
MACKINAW	-115.0124	-40.4306	-74.6118
MAG-EMIT	40.7036	33.1492	7.5585
MAGNESIT	-8.9460	-7.8155	-1.1304
MAGNETIT	47.7276	32.2493	15.4785
MELANTER	-8.3931	-2.5694	-5.8237
MIRABILI	-6.0088	-1.7701	-4.2386
NATRON	-9.7542	-1.8572	-7.8971
NESQUEHO	-8.9475	-5.4187	-3.5287
PYRITE	-210.3931	-90.3740	-120.0192
SIDERITE	-12.1350	-10.3647	-1.7703
THENARDI	-6.0037	-.1602	-5.8435
THERMONA	-9.7497	.2273	-9.9770
PYROLUSI	35.3330	43.2798	-7.9468
BIRNESSI	35.3330	44.4955	-9.1625
NSUTITE	35.3330	43.9055	-8.5725
BIXBYITE	44.0102	52.7207	-8.7105
HAUSMANN	52.6875	64.3058	-11.6183
PYROLUSI	8.6768	15.6755	-7.1985
MANGANIT	22.5024	26.6185	-4.1606
RHODOCHR	-10.4613	-10.3172	-.1441
MN(OH)2	-9.8307	2.1088	-11.9395
MNS GREE	-113.3550	-31.7497	-81.6053
MNSO4	-8.7364	3.2081	-9.9445
MNO(OH)	-2.0773	48.4187	-50.4960

SMITHSON	-11.0501	-9.8484	-1.2017
ZNCO3, 1	-11.0506	-10.2600	-.7906
ZNF2	-14.1688	-1.0653	-13.1035
ZN(OH)2	8.1084	11.5000	-3.3916
ZN2(OH)3	6.9602	15.2000	-8.2398
ZN5(OH)8	22.0288	38.5000	-16.4712
ZN2(OH)2	.8038	7.5000	-6.6962
ZN4(OH)6	17.0206	28.4000	-11.3794
ZNNO3)2,	-25.0457	3.2485	-28.2942
ZNO(ACTI	8.1089	11.3100	-3.2011
ZINCITE	8.1089	11.8999	-3.7909
ZN3O(SO4	-6.5004	21.1752	-27.6757
ZNS (A)	-113.9275	-44.9282	-68.9993
SPHALERI	-113.9275	-47.6574	-66.2701
WURTZITE	-113.9275	-45.6065	-68.3210
ZINCOSIT	-7.3047	3.6774	-10.9821
ZNSO4, 1	-7.3052	-.2001	-7.1051
BIANCHIT	-7.3077	-1.7544	-5.5533
GOSLAPIT	-7.3082	-2.0747	-5.2335
CD METAL	-20.7104	14.1157	-34.8261
GAMMA CD	-20.7104	14.2206	-34.9310
OTAVITE	-13.2138	-13.7198	.5060
CDCL2	-12.5687	-.5246	-12.0440
CDCL2, 1	-12.5692	-1.6467	-10.9224
CDCL2,2.	-12.5699	-1.9994	-10.5705
CDF2	-16.3324	-2.6421	-13.6903
CD(OH)2	5.9446	13.6500	-7.7054
CDOHCL	-3.3119	3.7776	-7.0895
CD3(OH)4	2.4212	22.5600	-20.1388
CD3OH2(S	-12.9919	6.7100	-19.7019
CD4(OH)6	8.3660	28.4000	-20.0340
MONTEPON	5.9453	15.9807	-10.0354
CDS(A)	-9.4697	.4124	-9.8821
CDS(A), 1	-9.4697	-1.3966	-8.0703
CDS(A),2	-9.4697	-1.7205	-7.7492
GREENOCK	-116.0911	-52.2493	-63.8419
ARGENOLI	-148.0160	-85.2916	-62.7244
CLAUSTI	-148.0160	-85.4755	-62.5406
ORIPMENT	-440.1173	-212.0799	-228.0374
REALGAR	-172.3653	-77.0456	-95.3039
ASZCS	-20.6766	6.8881	-27.5647
SCORO	-95.3807	-37.7146	-57.6662
CA3(ASO4	11.7665	22.3000	-10.5130
FEASO4.2	10.0024	13.7776	-3.7751
MN3ASO42	5.3312	12.5000	-7.1688
ZN3ASO42	3.6290	13.6500	-10.0210
LIME	10.8285	34.4081	-23.5796
PORTLAND	10.8280	23.7368	-12.9088
WUSTITE	8.0645	12.5538	-4.4893
PERICLAS	10.2131	22.7659	-12.5528
MAG-FERR	50.9169	45.8418	5.0751
LEPIDOCR	20.3516	14.7476	5.6040
FE(OH)3S	20.3511	16.0476	4.3035
NA2SO3	-32.6594	5.0529	-37.7123
K2SO3	-35.6295	8.2858	-43.9753
CASO3.2H	-31.2418	-3.5967	-27.6558
CASO3.5H	-31.2411	-3.1761	-28.1150
MGSO3	-31.8562	7.1400	-38.9962
CHALCAN	-175.7829	-43.0075	-82.5824
COSTBAS	-19.199[illegible]	-18.17[illegible]	[illegible]
OZ/GAS	53.3114	87.6895	-34.5581
CAMOL	-7.4375	-7.7443	.3109

STOP NUMBER :

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	3.245773D-08	-7.4887
TOT ALK	1.627574D-04	-3.7885
CA	1.412694D-04	-3.8500
CD	3.125531D-09	-8.5051
CL	2.791539D-05	-4.5542
F	3.856786D-07	-6.4138
FE	3.774324D-08	-7.4232
K	5.095435D-06	-5.2928
MG	3.269823D-05	-4.4855
MN	1.030448D-06	-5.9870
N	8.094009D-07	-6.0918
NA	1.624155D-04	-3.7894
S	2.120079D-04	-3.6736
U	3.111263D-07	-6.5071
ZN	3.270555D-07	-6.4854
MO	2.045911D-07	-6.6891

---- 1000 MIN IAP ----

PHASE	LOG IAP	LOG K	LOG IAP/K
URANINIT	-23.1544	-14.9746	-8.1797
UO2 (AM	-23.1544	-8.8075	-14.3075
U4O9 (C)	-64.6543	-42.6856	-21.9992
U3O8 (C)	-13.5978	-5.6903	-7.9075
UF4 (C)	-76.2270	-28.8566	-47.3704
UF4 0.5H	-76.2270	-39.0487	-37.1783
UO3 (C)	4.7783	9.0096	-4.2313
GUMMITE	4.7783	11.9359	-7.1576
B-UO2(OH	4.7783	6.4564	-1.6781
SCHOEPIT	4.7782	6.2043	-1.4261
RUTHERFO	-16.6701	-14.4662	-2.2039
ANHYDRIT	-7.6572	-4.3854	-3.2688
ARAGONIT	-11.6868	-8.1408	-3.5479
APATITE	-3.1956	11.5183	-14.7140
BRUCITE	9.1273	18.5147	-9.3874
CALCITE	-11.6888	-8.3933	-3.2955
DOLOMITE	-24.0118	-16.4457	-7.5661
EPSOMITE	-8.2914	-2.3282	-5.9632
FERRIHYD	19.7033	18.5875	1.1158
FE3(OH)8	45.1436	47.6249	-2.4813
FEOH(C)2.7	16.2875	10.6575	5.6235
FES PPT	-123.4121	-41.5940	-81.8175
FE2(SO4)	-10.8495	34.9210	-45.7705
FLUORITE	-16.7745	-11.2744	-5.5074
GOETHITE	19.7033	15.1640	4.5393
GREENITE	-471.4509	-168.3318	-303.1191
GYPSUM	-7.6572	-4.5474	-3.1098
HALITE	-6.3733	1.5186	-7.8919
HEMATITE	39.4266	25.4541	13.9725
HUMITE	-49.6577	-28.0976	-21.4701
LEPIDOCR	-40.1615	-5.2851	-34.8764

[illegible]	[illegible]	[illegible]	[illegible]
MAGNESIT	-12.3230	-7.6182	-4.7048
MAGNETIT	45.1436	34.5030	-10.6406
MELANTER	-11.6817	-2.6609	-9.0208
MIRABILI	-11.3479	-2.3775	-8.9704
NATRON	-15.3795	-2.3606	-13.0189
NESQUEHO	-12.3230	-5.2335	-7.0894
PYRITE	-224.6287	-94.5826	-130.0460
SIDERITE	-15.7133	-10.1942	-5.5191
THENARDI	-11.3479	-.1420	-11.2059
THERMONA	-15.3795	.3169	-15.6964
PYROLUSI	35.5579	45.0371	-9.4792
BIRNESSI	35.5579	45.3194	-9.7615
NSUTITE	35.5579	44.7294	-9.1715
BIXBYITE	43.1832	54.8560	-11.6728
HAUSMANN	50.8085	66.8891	-16.0806
PYROCROI	7.6253	16.5978	-8.9725
MANGANIT	21.5916	26.9894	-5.3978
RHODOCHR	-13.8250	-10.2712	-3.5538
MNCL2, 4	-15.1905	1.5499	-16.7404
MNS GREE	-121.5238	-33.4877	-88.0361
MNSO4	-9.7934	3.7032	-13.4966
MN2(SO4)	-9.0729	51.3440	-60.4189
ZN METAL	-20.8110	28.2150	-49.0259
ZNCL2	-15.6941	8.1967	-23.8909
SMITHSON	-14.3287	-9.7090	-4.6197
ZNCO3, 1	-14.3287	-10.2600	-4.0687
ZNFC	-19.4147	-.6469	-18.7677
ZN(OH)C	7.1216	11.5000	-4.3784
ZN2(OH)3	2.8354	15.2000	-12.3646
ZN5(OH)8	12.7924	38.5000	-25.7076
ZN(OH)2	-3.1754	7.5000	-10.6754
ZN2(OH)6	11.0678	29.4000	-17.3322
ZNNO3(OH)	-31.0501	3.0722	-34.1523
ZN(OH)F1	7.1216	11.7100	-4.1584
ZINCITE	7.1216	12.5991	-5.4775
ZN3(PO4)	-13.4705	23.1563	-36.6306
ZNS [illegible]	-122.0275	-46.9691	-75.0584
SPHALERI	-122.0275	-49.8445	-72.1830
WURTZITE	-122.0275	-47.6919	-74.3356
ZINCOSIT	-10.2971	4.2915	-14.5886
ZNSO4, 1	-10.2971	.1402	-10.4373
BIANCHIT	-10.2971	-1.7493	-8.5478
GOSLARIT	-10.2971	-2.1855	-8.1116
CD METAL	-22.8375	14.6915	-37.5289
GAMMA CD	-22.8375	14.8008	-37.6383
OTAVITE	-16.7552	-13.7013	-2.6539
CDCL2	-17.7206	-.3816	-17.3390
CDCL2, 1	-17.7276	-1.5885	-16.1321
CDCL2,2	-17.7207	-2.0541	-15.6665
CDF2	-21.4412	-2.3312	-19.1100
CD(OH)2	5.0981	13.6500	-8.5549
CDOHCL	-6.3126	4.0146	-10.3274
CD3(OH)4	-2.1333	22.5600	-24.6933
CD3(PO4)2	-19.5520	6.7100	-26.2620
CD4(OH)6	2.9619	28.4000	-25.4381
MONTEPON	5.0981	16.7707	-11.6726
CDS,A	-12.3036	.8879	-13.2015
CDSO4, 1	-12.3036	-1.1581	-11.1455
CDSO4,3	-12.3036	-1.5830	-10.7206
GREENOCK	-124.0542	-54.6967	-69.3575
AFBENOCK	-161.9341	-89.5517	-72.3843
CLAUDET,	-161.9341	-69.7417	-92.1923
OPIMENT	-468.4146	-222.4721	-245.9426
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
CA3(ASO4	4.1825	22.3000	-18.1175
FEASO4.2	7.1523	14.0975	-6.9452
MN3ASO42	-2.2261	12.5000	-14.7261
ZN3ASO42	-3.7371	13.6500	-17.3871
LIME	9.7615	35.8877	-26.1262
PORTLAND	9.7615	24.7185	-14.9570
WUSTITE	6.9134	13.3487	-6.4353
PERICLAS	9.1274	23.9216	-14.7942
MAG-FERR	48.5340	48.6130	-.0790
LEPIDOCR	19.7033	15.0675	4.6358
FE(OH)3S	19.7033	16.3675	3.3358
NA2SO3	-39.2805	5.1476	-44.4280
K2SO3	-42.2877	8.3555	-50.6432
CASO3.2H	-35.5898	-3.6836	-31.9062
CASO3.5H	-35.5898	-3.1133	-32.4765
MGSO3	-36.2240	7.7288	-43.9528
CH4(GAS)	-133.1808	-45.1516	-88.0292
CO2(GAS)	-21.4503	-18.1954	-3.2549
O2(GAS)	55.8652	92.2397	-36.3745
CAMOO4	-10.6633	-7.7667	-2.8966

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	3.2457730-05	-7.4887
C	1.6275740-04	-3.7885
CA	1.4126940-04	-3.8500
CT	3.1255310-09	-8.5051
CL	2.7915390-05	-4.5542
F	3.8567660-07	-6.4135
FE	3.7743740-08	-7.4277
H	5.0954350-06	-5.2919
MG	3.2495070-05	-4.4899
MN	1.0304460-06	-5.9877
N	8.0940090-07	-6.0910
NA	1.6241550-04	-3.7894
P	2.1200790-04	-3.6736
S	3.1119630-07	-6.5071
ZN	3.0705550-07	-6.[illegible]
MO	2.0459110-07	-6.6891

----DESCRIPTION OF SOLUTION----

PH =	6.8793
PE =	7.1270
ACTIVITY H2O =	1.0000
IONIC STRENGTH =	.0009
TEMPERATURE =	.1150
ELECTRICAL BALANCE =	-4.0264D-05
TDS =	1.9246D-03
TOTAL ALKALINITY =	1.0000D-02
ITERATIONS =	49

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.49594D-07	-6.8251	1.44762D-07	-6.8393	9.67700D-01	-.0143
2	E-	-1.0	7.46512D-08	-7.1270	7.46512D-08	-7.1270	1.00000D+00	.0000
3	H2O	.0	9.99987D-01	.0000	9.99987D-01	.0000	1.00000D+00	.0000
6	H3ASO4	.0	2.81126D-13	-12.5511	2.81185D-13	-12.5510	1.00021D+00	.0000
10	CO3 2-	-2.0	1.92933D-08	-7.7146	1.69188D-08	-7.7716	8.76924D-01	-.0570
11	CA 2+	2.0	1.37627D-04	-3.8613	1.21014D-04	-3.9172	8.79289D-01	-.0559
12	CD 2+	2.0	2.97505D-09	-8.5265	2.60889D-09	-8.5835	8.76924D-01	-.0570
13	CL-	-1.0	2.79153D-05	-4.5542	2.70054D-05	-4.5685	9.67400D-01	-.0144
16	F-	-1.0	3.84978D-07	-6.4146	3.72543D-07	-6.4288	9.67700D-01	-.0143
17	FE 2+	2.0	1.30427D-08	-7.8846	1.14375D-08	-7.9417	8.76924D-01	-.0570
19	K+	1.0	5.09138D-06	-5.2932	4.92544D-06	-5.3076	9.67407D-01	-.0144
21	MG 2+	2.0	3.19335D-05	-4.4958	2.80975D-05	-4.5513	8.79875D-01	-.0556
22	MN 2+	2.0	1.00846D-06	-5.9963	8.84346D-07	-6.0534	8.76924D-01	-.0570
23	NO3 -	-1.0	5.65935D-13	-12.2472	5.47655D-13	-12.2615	9.67700D-01	-.0143
24	NA+	1.0	1.62286D-04	-3.7897	1.57066D-04	-3.8039	9.67831D-01	-.0142
29	SO4 2-	-2.0	2.07534D-04	-3.6829	1.81961D-04	-3.7400	8.76777D-01	-.0571
32	UO2 2+	2.0	1.43421D-09	-8.8434	1.25769D-09	-8.9004	8.76924D-01	-.0570
34	ZN 2+	2.0	3.16223D-07	-6.5000	2.77304D-07	-6.5570	8.76924D-01	-.0570
35	MOO4 2-	-2.0	2.04591D-07	-6.6891	1.79411D-07	-6.7462	8.76924D-01	-.0570
51	H3ASO3	.0	9.19840D-20	-19.0363	9.20033D-20	-19.0362	1.00021D+00	.0000
53	FE 3+	3.0	4.11298D-15	-14.3856	3.06070D-15	-14.5142	7.44157D-01	-.1288
54	MN 3+	3.0	9.45172D-27	-26.0245	7.03356D-27	-26.1526	7.44157D-01	-.1288
55	NH4 +	1.0	8.05466D-07	-6.0940	7.79449D-07	-6.1082	9.67700D-01	-.0143
56	NO2 -	-1.0	2.04653D-09	-8.6890	1.98043D-09	-8.7030	9.67700D-01	-.0143
61	UO2 +	1.0	9.82056D-14	-13.0079	9.50335D-14	-13.0221	9.67700D-01	-.0143
65	OH-	-1.0	9.22265D-09	-8.0351	8.92475D-09	-8.0494	9.67700D-01	-.0143
75	NH4SO4 -	-1.0	1.88811D-09	-8.7240	1.82712D-09	-8.7382	9.67700D-01	-.0143
76	MGOH +	1.0	3.15915D-11	-10.5004	3.05711D-11	-10.5147	9.67700D-01	-.0143
77	MGF +	1.0	3.48435D-10	-9.4579	3.37184D-10	-9.4721	9.67700D-01	-.0143
78	[illegible] AQ	.0	3.09502D-10	-9.5093	3.09556D-10	-9.5092	1.00021D+00	.0000
79	[illegible]-CO3 +	1.0	3.09502D-08	-7.5100	2.99924D-08	-7.5244	9.67700D-01	-.0143
80	MGSO4 AQ	.0	7.3[illegible]-07	-6.1348	7.33276D-07	-6.1347	1.00021D+00	.0000
84	CAO- +	1.0	2.[illegible]D-11	-10.6317	2.25945D-11	-10.6460	9.67700D-01	-.0143
85	CAHCO3 +	1.0	6.[illegible]-08	-7.2053	6.03109D-08	-7.2196	9.67700D-01	-.0143
86	CACO3 AQ	.0	2.10085D-09	-8.6776	2.10133D-09	-8.6775	1.00021D+00	.0000
87	CASO4 AQ	.0	3.57770D-06	-5.4464	3.57845D-06	-5.4463	1.00021D+00	.0000
91	[illegible] +	1.0	2.26342D-10	-9.6450	2.19031D-10	-9.6595	9.67700D-01	-.0143
92	[illegible] -	-1.0	1.29377D-11	-10.8881	1.25218D-11	-10.9023	9.67700D-01	-.0143
93	NAHCO3 A	.0	4.62398D-09	-8.3350	4.62495D-09	-8.3349	1.00021D+00	.0000
94	NASO4 -	-1.0	1.24613D-07	-6.9044	1.20588D-07	-6.9187	9.67700D-01	-.0143
96	NAF AQ	.0	9.48780D-12	-11.0228	9.48981D-12	-11.0227	1.00021D+00	.0000
97	KSO4 -	-1.0	4.05291D-09	-8.3922	3.92200D-09	-8.4065	9.67700D-01	-.0143
109	FEOH +	1.0	3.39572D-12	-11.4691	3.28603D-12	-11.4833	9.67700D-01	-.0143
110	FEOH3 -1	-1.0	3.69967D-21	-20.4318	3.58017D-21	-20.4461	9.67700D-01	-.0143
111	FESO4 AQ	.0	2.25229D-10	-9.6474	2.25276D-10	-9.6473	1.00021D+00	.0000
113	FEOH2 AQ	.0	1.82088D-17	-16.7397	1.82126D-17	-16.7396	1.00021D+00	.0000
117	FEOH 2+	2.0	3.14841D-11	-10.5019	2.76090D-11	-10.5589	8.76924D-01	-.0570
119	FESO4 +	1.0	2.62468D-15	-14.5809	2.53990D-15	-14.5952	9.67700D-01	-.0143
120	FECL 2+	2.0	1.20372D-18	-17.9195	1.05557D-18	-17.9765	8.76924D-01	-.0570
121	FECL2 +	1.0	3.11159D-22	-21.5070	3.01108D-22	-21.5213	9.67700D-01	-.0143
122	FECL3 AQ	.0	8.17985D-28	-27.0899	8.13155D-28	-27.0898	1.00021D+00	.0000
123	FEOH2 +	1.0	2.40286D-08	-7.6193	2.32525D-08	-7.6335	9.67700D-01	-.0143
124	FEOH3 AQ	.0	3.99549D-10	-9.3984	3.99632D-10	-9.3983	1.00021D+00	.0000
125	FEO-4 -	-1.0	1.22504D-11	-10.9119	1.18547D-11	-10.9261	9.67700D-01	-.0143
127	FEF 2-	2.0	1.35795D-15	-14.8671	1.19082D-15	-14.9240	8.76924D-01	-.0570
128	FEF2 +	1.0	1.32448D-17	-16.8780	1.28172D-17	-16.8922	9.67700D-01	-.0143
129	FEF3 AQ	.0	6.90064D-21	-20.1611	6.90209D-21	-20.1610	1.00021D+00	.0000
130	FE(SO4)2	-1.0	1.35831D-17	-16.8670	1.31444D-17	-16.8813	9.67700D-01	-.0143
131	FE2(OH)2	4.0	1.06508D-19	-18.9726	6.29542D-20	-19.2008	5.91355D-01	-.0228
132	FE3(OH)4	5.0	8.25668D-24	-23.0830	3.63353D-24	-23.4397	4.40261D-01	-.3567
134	MNCL +	1.0	9.98465D-11	-10.0007	9.66214D-11	-10.0149	9.67700D-01	-.0143
137	MNCL2 AQ	.0	7.08653D-16	-15.1496	7.08801D-16	-15.1495	1.00021D+00	.0000

141	MNF +	1.0	2.41023D-12	-11.6179	2.33237D-12	-11.6322	9.67700D-01	-.0143
142	MNSO4 AQ	.0	2.09734D-08	-7.6783	2.09778D-08	-7.6782	1.00021D+00	.0000
143	MN(NO3)2	.0	1.12196D-30	-29.9500	1.12220D-30	-29.9499	1.00021D+00	.0000
144	MNHCO3 +	1.0	8.91061D-10	-9.0501	8.62279D-10	-9.0644	9.67700D-01	-.0143
162	ZNCL +	1.0	6.29080D-12	-11.2013	6.08760D-12	-11.2156	9.67700D-01	-.0143
163	ZNCL2 AQ	.0	1.54318D-16	-15.8116	1.54350D-16	-15.8115	1.00021D+00	.0000
164	ZNCL3 -	-1.0	4.10644D-21	-20.3865	3.97380D-21	-20.4008	9.67700D-01	-.0143
165	ZNCL4 2-	-2.0	4.93456D-26	-25.3068	4.32724D-26	-25.3638	8.76924D-01	-.0570
166	ZNF +	1.0	1.07204D-12	-11.9698	1.03742D-12	-11.9840	9.67700D-01	-.0143
167	ZNOH +	1.0	2.64368D-10	-9.5778	2.55829D-10	-9.5921	9.67700D-01	-.0143
168	ZN(OH)2	.0	6.82650D-12	-11.1658	6.82793D-12	-11.1657	1.00021D+00	.0000
169	ZN(OH)3	-1.0	4.17385D-17	-16.3795	4.03903D-17	-16.3937	9.67700D-01	-.0143
170	ZN(OH)4	-2.0	5.51432D-24	-23.2585	4.83564D-24	-23.3155	8.76924D-01	-.0570
171	ZNOHCL A	.0	1.71260D-12	-11.7663	1.71295D-12	-11.7663	1.00021D+00	.0000
174	ZNSO4 AQ	.0	9.59550D-09	-8.0179	9.59751D-09	-8.0178	1.00021D+00	.0000
175	ZN(SO4)2	-2.0	1.99504D-11	-10.7000	1.74950D-11	-10.7571	8.76924D-01	-.0570
180	ZNHCO3 +	1.0	8.83570D-20	-19.0538	8.55030D-20	-19.0680	9.67700D-01	-.0143
181	ZNCO3 AQ	.0	9.35912D-10	-9.0288	9.36108D-10	-9.0287	1.00021D+00	.0000
182	ZN(CO3)2	-2.0	3.86130D-13	-12.4133	3.38606D-13	-12.4703	8.76924D-01	-.0570
183	CDCL +	1.0	6.35017D-12	-11.1972	6.14506D-12	-11.2115	9.67700D-01	-.0143
184	CDCL2 AQ	.0	6.25894D-16	-15.2035	6.26025D-16	-15.2034	1.00021D+00	.0000
185	CDCL3 -	-1.0	7.30726D-21	-20.1362	7.07123D-21	-20.1505	9.67700D-01	-.0143
186	CDF +	1.0	1.26442D-14	-13.8981	1.22358D-14	-13.9124	9.67700D-01	-.0143
187	CDF2 AQ	.0	1.14477D-20	-19.9413	1.14501D-20	-19.9412	1.00021D+00	.0000
188	CD(CO3)3	-4.0	3.54561D-26	-25.4513	2.09683D-26	-25.6764	5.91355D-01	-.2283
189	CDOH +	1.0	2.68559D-13	-12.6543	2.60173D-13	-12.6986	9.67700D-01	-.0143
190	CD(OH)2	.0	5.55958D-16	-15.2550	5.56074D-16	-15.2549	1.00021D+00	.0000
191	CD(OH)3	-1.0	4.45381D-22	-21.3513	4.30995D-22	-21.3655	9.67700D-01	-.0143
192	CD(OH)4	-2.0	3.02586D-29	-28.5190	2.65345D-29	-28.5760	8.76924D-01	-.0570
193	CD2OH +3	3.0	4.82067D-21	-20.3169	3.58734D-21	-20.4452	7.44157D-01	-.1283
194	CDOHCL A	.0	9.83910D-15	-14.0075	9.83016D-15	-14.0074	1.00021D+00	.0000
195	CDNO3 +	1.0	8.28927D-21	-20.0847	7.96049D-21	-20.0990	9.67700D-01	-.0143
196	CDSO4 AQ	.0	1.15546D-10	-9.9357	1.15970D-10	-9.9357	1.00021D+00	.0000
205	CDHCO3 +	1.0	1.65863D-11	-10.7803	1.60502D-11	-10.7945	9.67700D-01	-.0143
206	CDCO3 AQ	.0	1.10595D-11	-10.9563	1.10616D-11	-10.9562	1.00021D+00	.0000
207	CD(SO4)2	-2.0	3.11495D-13	-12.5065	2.73158D-13	-12.5674	8.76924D-01	-.0570
208	H2AsO3 -	-1.0	1.41757D-22	-21.8487	1.37176D-22	-21.8637	9.67700D-01	-.0143
264	H4AsO3 2-	-2.0	2.64109D-28	-27.5781	2.31604D-28	-27.6357	8.76924D-01	-.0570
268	H4AsO3 +	1.0	6.81856D-27	-26.1667	6.59571D-27	-26.1805	9.67700D-01	-.0143
269	H2AsO4 -	-1.0	1.47730D-08	-7.8276	1.43926D-08	-7.8419	9.67700D-01	-.0143
270	H4AsO4 2-	-2.0	1.75643D-08	-7.7549	1.54201D-08	-7.8119	8.76924D-01	-.0570
271	AsO4 -3	-3.0	1.85585D-13	-12.7316	1.38357D-13	-12.8589	7.44157D-01	-.1283
272	HCO3 -	-1.0	1.06479D-04	-3.9727	1.03040D-04	-3.9870	9.67700D-01	-.0143
273	H2CO3 AQ	.0	5.56393D-05	-4.2531	5.58510D-05	-4.2530	1.00021D+00	.0000
274	HSO4 -	-1.0	1.36667D-09	-8.8643	1.32272D-09	-8.8785	9.67700D-01	-.0143
275	HF AQ	.0	4.67515D-11	-10.3302	4.67613D-11	-10.3301	1.00021D+00	.0000
276	HF2 -	-1.0	5.78852D-17	-16.2374	5.60155D-17	-16.2517	9.67700D-01	-.0143
277	H2F2 AQ	.0	1.70441D-20	-19.7684	1.70476D-20	-19.7683	1.00021D+00	.0000
284	U(OH)2 +	2.0	1.92609D-29	-28.7153	1.68904D-29	-28.7724	8.76924D-01	-.0570
285	U(OH)3 +	1.0	1.22511D-25	-24.9118	1.18554D-25	-24.9261	9.67700D-01	-.0143
286	U(OH)4 A	.0	1.61805D-22	-21.7913	1.61839D-22	-21.7909	1.00021D+00	.0000
287	U(OH)5 -	-1.0	1.76973D-20	-19.7472	1.73192D-20	-19.7615	9.67700D-01	-.0143
301	UO2O- +1	1.0	1.51804D-08	-7.8187	1.46900D-08	-7.8330	9.67700D-01	-.0143
302	UO2)2OH2	2.0	4.04461D-11	-10.3930	3.54814D-11	-10.4500	8.76924D-01	-.0570
303	UO2.3OH5	1.0	1.74979D-10	-9.7570	1.69327D-10	-9.7713	9.67700D-01	-.0143
304	UO2CO3 A	.0	2.69[illegible]D-07	-6.5689	2.69917D-07	-6.5688	1.00021D+00	.0000
305	UO2CO3 -2	-2.0	2.35115D-08	-7.6230	2.05811D-08	-7.6800	8.76924D-01	-.0570
306	UO2CO3 3	-4.0	9.61356D-11	-10.0171	5.65491D-11	-10.2457	5.91355D-01	-.2283
307	UO2F +1	1.0	6.60763D-11	-10.1800	6.35400D-11	-10.1940	9.67700D-01	-.0143
308	UO2F2 AQ	.0	1.66889D-13	-12.7781	1.64724D-13	-12.7860	1.00021D+00	.0000
309	UO2F3 -1	-1.0	1.77050D-17	-16.7519	1.71330D-17	-16.7667	9.67700D-01	-.0143
310	UO2F4 2-	-2.0	1.30355D-20	-21.8883	1.14065D-20	-21.9383	8.76924D-01	-.0570
311	UO2F5 3-	-3.0	4.61977D-14	-13.3353	4.66765D-14	-13.3313	9.67700D-01	-.0143

STEP NUMBER 4

.020 = FRACTION OF SOLUTION 1. .980 = FRACTION OF SOLUTION 2.

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	6.491546D-08	-7.1877
C	3.255148D-04	-3.4874
CA	2.825388D-04	-3.5489
CD	6.251061D-09	-8.2040
CL	5.583077D-05	-4.2531
F	7.713572D-07	-6.1127
FE	7.548648D-08	-7.1221
K	1.019087D-05	-4.9918
MG	6.539645D-05	-4.1844
MN	2.060895D-06	-5.6859
N	1.618802D-06	-5.7908
NA	3.248310D-04	-3.4863
S	4.240157D-04	-3.3726
U	6.222526D-07	-6.2063
ZN	6.541110D-07	-6.1843
MO	4.091822D-07	-6.3661

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-22.5105	-14.9693	-7.5412
UO2 (AM	-22.8105	-8.8746	-13.9359
U4O9 (C)	-63.6759	-42.6733	-21.0065
U3O8 (C)	-13.3071	-5.6946	-7.6126
UF4 (C)	-74.6690	-28.8514	-45.8177
UF4.2.5H	-74.6691	-39.0373	-35.6317
UCT (C)	4.7517	9.0031	-4.2514
GUMMITE	4.7517	11.9281	-7.1764
B-UO2(OH	4.7517	6.4518	-1.7001
SCHOEPIT	4.7517	6.2003	-1.4486
RUTHERFO	-16.3936	-14.4656	-1.9280
ANHYDRIT	-7.1136	-4.3896	-2.7240
ARAGONIT	-11.1293	-8.1416	-2.9877
ARTINITE	-2.3796	11.5086	-13.8863
BRUCITE	9.3829	18.5061	-9.1232
CALCITE	-11.1293	-8.3933	-2.7360
DOLOMITE	-22.8918	-16.4495	-6.4423
EPSOMITE	-7.7468	-2.3273	-5.4196
FERRIHYD	19.8970	18.5641	1.3329
FE3(OH)8	45.9100	47.6197	-1.7097
FEOH)2.7	16.5658	10.6541	5.9117
FE3 BET	-121.2614	-41.5339	-79.6585
FE2(SO4)	-11.5945	34.8511	-46.4457
FLUORITE	-19.9133	-11.3719	-4.6415
GOETHITE	19.5970	15.1557	4.7413
GREIGITE	-443.6079	-168.2976	-295.3103
GYPSUM	-7.1176	-2.5677	-2.[illegible]

HYDRMAGN	-37.6670	-5.3027	-32.3643
JAROSITE	25.4318	32.6549	-7.2230
MACKINAW	-121.2624	-42.3039	-78.9585
MAGHEMIT	39.7941	33.7782	6.0159
MAGNESIT	-11.7625	-7.6202	-4.1422
MAGNETIT	45.9100	34.4793	11.4307
MELANTER	-11.0137	-2.6599	-8.3538
MIRABILI	-10.4853	-2.3711	-8.1141
NATRON	-14.5010	-2.3553	-12.1457
NESQUEHO	-11.7625	-5.2355	-6.5270
PYRITE	-221.0786	-94.5383	-126.5403
SIDERITE	-15.0294	-10.1960	-4.8333
THENARDI	-10.4852	-.1421	-10.3430
THERMONA	-14.5009	.3160	-14.8168
PYROLUSI	35.4424	45.0186	-9.5762
BIRNESSI	35.4424	45.3107	-9.8683
NSUTITE	35.4424	44.7207	-9.2783
BIXBYITE	43.3227	54.8336	-11.5109
HAUSMANN	51.2030	66.8622	-15.6592
PYROCROI	7.8802	16.5902	-8.7100
MANGANIT	21.6613	26.9807	-5.3194
RHODOCHR	-13.2651	-10.2719	-2.9932
MNCL2, 4	-14.3276	1.5556	-15.8834
MNS GREE	-119.4981	-33.4694	-86.0287
MNSO4	-9.2494	3.6980	-12.9474
MNCO3(S)	-8.0681	51.3155	-59.3836
ZN METAL	-20.1893	26.0026	-46.3919
ZNCL2	-14.8349	8.1909	-23.0258
SMITHSON	-13.7724	-9.7104	-4.0620
ZNO(S), 1	-13.7724	-10.2600	-3.5124
ZNF2	-18.5564	-.6513	-17.9051
ZN(OH)2	7.3729	11.5000	-4.1271
ZN2(OH)3	3.6419	15.2000	-11.5581
ZN5(OH)8	14.6566	38.5000	-23.8434
ZN2(OH)2	-0.3679	7.5000	-9.8619
ZN(OH)6	12.3619	28.[illegible]	-16.0381
ZNS(S)	-32.3319	3.3841	-36.1660
ZNCO3(S)	7.3729	11.3100	-3.9371
ZINCITE	7.3729	12.5917	-5.2188
ZN2SIO4	-12.1435	23.1375	-35.2780
ZNS (A)	-120.0055	-46.9477	-73.0578
SPHALERI	-120.0055	-49.8118	-70.1937
WURTZITE	-120.0055	-47.6700	-72.3355
ZINCOSIT	-9.7567	4.2651	-14.0418
ZNSO4, 1	-9.7567	.1366	-9.8933
BIANCHIT	-9.7568	-1.7494	-8.0074
GOSLARIT	-9.7568	-2.1792	-7.5776
CD METAL	-22.2214	14.6854	-36.9068
GAMMA CD	-22.2214	14.7947	-37.0161
OTAVITE	-15.8045	-13.7015	-2.1031
CDCL2	-16.6670	-.3831	-16.4839
CDCL2, 1	-16.6671	-1.5891	-15.2779
CDCL2,2	-16.8671	-2.0536	-14.8135
CDF2	-20.5885	-2.3345	-18.2540
CD(OH)2	5.3408	13.6500	-8.3092
CDOHCL	-5.7631	4.0131	-9.7762
CD3(OH)4	-1.1377	22.5600	-23.6977
CD3OH2(S)	-18.2279	6.7100	-24.9379
CD4(OH)6	4.2334	28.4000	-24.1666
MONTEPON	5.3408	16.7643	-11.4235
CDSO4	-11.7888	.6789	-12.4677
CDSO4, 1	-11.7888	-1.1475	-10.6413
CDSO4,2	-11.7888	-1.5644	-10.2244

ARSENOLI	-159.2516	-89.5050	-69.7466
CLAUDETI	-159.2516	-89.6959	-69.5557
ORIPMENT	-461.7610	-222.3133	-239.4477
REALGAR	-180.9724	-80.8658	-100.1066
AS2O5	-24.5014	7.0593	-31.5607
SULFUR	-99.8162	-39.4850	-60.3312
CA3(ASO4	5.5466	22.3000	-16.7534
FEASO4.2	7.6463	14.0941	-6.4478
MN3ASO42	-.8607	12.5000	-13.3607
ZN3ASO42	-2.3828	13.6500	-16.0328
LIME	10.0160	35.8722	-25.8562
PORTLAND	10.0160	24.7081	-14.6922
WUSTITE	7.2526	13.3403	-6.0877
PERICLAS	9.3829	23.9094	-14.5266
MAG-FERR	49.1769	48.5838	.5931
LEPIDOCR	19.8970	15.0641	4.8329
FE(OH)3S	19.8970	16.3641	3.5329
NA2SO3	-38.0474	5.1466	-43.1939
K2SO3	-41.0550	8.3548	-49.4098
CASO3.2H	-34.6758	-3.6826	-30.9933
CASO3.5H	-34.6758	-3.1134	-31.5624
MGSO3	-35.3089	7.7226	-43.0316
CH4(GAS)	-131.3941	-45.1311	-86.2630
CO2(GAS)	-21.1453	-18.1952	-2.9501
O2(GAS)	55.1244	92.1937	-37.0693
CAMOO4	-10.1125	-7.7665	-2.3460

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	6.491540D-05	-7.1877
C	3.255148D-04	-3.4874
CA	2.825388D-04	-3.5489
CD	6.251066D-09	-8.2040
CL	5.583977D-05	-4.2531
F	7.713572D-07	-6.1127
FE	7.546645D-08	-7.1221
K	1.019087D-05	-4.9918
MG	6.539654D-05	-4.1844
MN	2.068858D-06	-5.6888
N	1.615607D-06	-5.7928
NA	3.248310D-04	-3.4883
S	4.240157D-04	-3.3726
U	6.222526D-07	-6.2060
ZN	6.541110D-07	-6.1843
MO	4.091822D-07	-6.3881

----DESCRIPTION OF SOLUTION----

PH =	6.87[illegible]
PE =	6.957[illegible]
ACTIVITY H2O =	1.000[illegible]
IONIC STRENGTH =	.0815
TEMPERATURE =	.230[illegible]
ELECTRICAL BALANCE =	-6.05270-[illegible]
TDS =	3.8495D-[illegible]
TOTAL ALKALINITY =	2.1442D-[illegible]
ITERATIONS =	3[illegible]

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.54486D-07	-6.8111	1.47633D-07	-6.8308	9.55637D-01	-.0197
2	E-	-1.0	1.12128D-07	-6.9503	1.12128D-07	-6.9503	1.00000D+00	.0000
3	H2O	.0	9.99975D-01	-.0000	9.99975D-01	-.0000	1.00000D+00	.0000
6	H3ASO4	.0	5.61173D-13	-12.2509	5.61405D-13	-12.2507	1.00041D+00	.0002
10	CO3 2-	-2.0	3.93674D-08	-7.4049	3.28328D-08	-7.4837	8.34011D-01	-.0788
11	CA 2+	2.0	2.69778D-04	-3.5690	2.26141D-04	-3.6456	8.38252D-01	-.0766
12	CD 2+	2.0	5.72766D-09	-8.2420	4.77693D-09	-8.3209	8.34011D-01	-.0788
13	CL-	-1.0	5.58303D-05	-4.2531	5.33218D-05	-4.2731	9.55069D-01	-.0200
16	F-	-1.0	7.68927D-07	-6.1141	7.34815D-07	-6.1338	9.55637D-01	-.0197
17	FE 2+	2.0	3.41308D-08	-7.4669	2.84655D-08	-7.5457	8.34011D-01	-.0788
19	K+	1.0	1.01757D-05	-4.9924	9.71848D-06	-5.0124	9.55069D-01	-.0200
21	MG 2+	2.0	6.27071D-05	-4.2027	5.26307D-05	-4.2788	8.39310D-01	-.0761
22	MN 2+	2.0	1.98363D-06	-5.7025	1.65437D-06	-5.7814	8.34011D-01	-.0766
23	NO3 -	-1.0	4.15083D-14	-13.3819	3.96669D-14	-13.4016	9.55637D-01	-.0197
24	NA+	1.0	3.24346D-04	-3.4890	3.10036D-04	-3.5086	9.55879D-01	-.0196
29	SO4 2-	-2.0	4.08325D-04	-3.3890	3.40415D-04	-3.4680	8.33686D-01	-.0790
32	UO2 2+	2.0	1.47532D-09	-8.8311	1.23044D-09	-8.9099	8.34011D-01	-.0766
34	ZN 2+	2.0	6.16740D-07	-6.2099	5.14368D-07	-6.2887	8.34011D-01	-.0788
35	MOO4 2-	-2.0	4.09182D-07	-6.3881	3.41263D-07	-6.4669	8.34011D-01	-.0788
51	H3ASO3	.0	4.20945D-19	-18.3758	4.21119D-19	-18.3756	1.00041D+00	.0002
53	FE 3+	3.0	7.68883D-15	-14.1141	5.11088D-15	-14.2915	6.64717D-01	-.1774
54	MN 3+	3.0	1.34443D-26	-25.8715	8.93663D-27	-26.0485	6.64717D-01	-.1774
55	NH4 +	1.0	1.61139D-06	-5.7929	1.53991D-06	-5.8125	9.55637D-01	-.0197
56	NO2 -	-1.0	3.40469D-10	-9.4679	3.25365D-10	-9.4876	9.55637D-01	-.0197
61	UO2 +	1.0	1.45759D-13	-12.8364	1.39293D-13	-12.8561	9.55637D-01	-.0197
65	OH-	-1.0	9.25253D-09	-8.0337	8.84206D-09	-8.0534	9.55637D-01	-.0197
75	NH4SO4 -	-1.0	7.06636D-09	-8.1508	6.75287D-09	-8.1705	9.55637D-01	-.0197
76	MGOH +	1.0	5.94481D-11	-10.2259	5.68106D-11	-10.2456	9.55637D-01	-.0197
77	MGF +	1.0	1.30834D-09	-8.8833	1.25030D-09	-8.9030	9.55637D-01	-.0197
78	MGCO3 AQ	.0	1.12689D-09	-8.9461	1.12735D-09	-8.9479	1.00041D+00	.0002
79	MGHCO3 +	1.0	1.15544D-07	-6.9373	1.10418D-07	-6.9570	9.55637D-01	-.0197
80	MGSO4 AQ	.0	2.57134D-06	-5.5896	2.57240D-06	-5.5897	1.00041D+00	.0002
84	CAO- +	1.0	4.38140D-11	-10.3564	4.18703D-11	-10.3781	9.55637D-01	-.0197
85	CAHCO3 +	1.0	2.33298D-07	-6.6321	2.22949D-07	-6.6518	9.55637D-01	-.0197
86	CACO3 AQ	.0	7.61949D-09	-8.1181	7.62264D-09	-8.1179	1.00041D+00	.0002
87	CASO4 AQ	.0	1.25195D-05	-4.9024	1.25246D-05	-4.9022	1.00041D+00	.0002
91	CAF +	1.0	8.47300D-10	-9.0728	8.09711D-10	-9.0917	9.55637D-01	-.0197
92	NACO3 -	-1.0	5.05406D-11	-10.2964	4.82955D-11	-10.3161	9.55637D-01	-.0197
93	NAHCO3 A	.0	1.80603D-08	-7.7433	1.80677D-08	-7.7431	1.00041D+00	.0002
94	NASO4 -	-1.0	4.66386D-07	-6.3313	4.45697D-07	-6.3510	9.55637D-01	-.0197
96	NAF AQ	.0	3.69327D-11	-10.4326	3.69479D-11	-10.4324	1.00041D+00	.0002
97	KSO4 -	-1.0	1.51857D-08	-7.8186	1.45120D-08	-7.8383	9.55637D-01	-.0197
109	FEOH +	1.0	8.47765D-12	-11.0717	8.10156D-12	-11.0914	9.55637D-01	-.0197
110	FEOH3 -1	-1.0	8.99902D-21	-20.0458	8.59980D-21	-20.0655	9.55637D-01	-.0197
111	FESO4 AQ	.0	1.05109D-09	-8.9784	1.05153D-09	-8.9782	1.00041D+00	.0002
113	FEOH2 AQ	.0	4.45377D-17	-16.3513	4.45561D-17	-16.3511	1.00041D+00	.0002
117	FEOH 2+	2.0	5.46417D-11	-10.2625	4.55718D-11	-10.3413	8.34011D-01	-.0788
119	FESO4 +	1.0	8.32807D-15	-14.0795	7.95861D-15	-14.0992	9.55637D-01	-.0197
120	FEO 2+	2.0	4.19112D-18	-17.3777	3.49542D-18	-17.4565	8.34011D-01	-.0788
121	FEOL2 +	1.0	2.05122D-21	-20.6880	1.96022D-21	-20.7077	9.55637D-01	-.0197
122	FEOL3 AQ	.0	1.04479D-26	-25.9810	1.04523D-26	-25.9808	1.00041D+00	.0002
123	FEOH +	1.0	3.95796D-08	-7.4025	3.78337D-08	-7.4222	9.55637D-01	-.0197
124	FEOH2 AQ	.0	6.42162D-10	-9.1920	6.42425D-10	-9.1918	1.00041D+00	.0002
125	FEOH4 -	-1.0	1.96370D-11	-10.7069	1.87658D-11	-10.7266	9.55637D-01	-.0197
127	FEF 2+	2.0	4.71258D-15	-14.3267	3.93034D-15	-14.4056	8.34011D-01	-.0788
128	FEFO +	1.0	8.74554D-17	-16.0580	8.35756D-17	-16.0778	9.55637D-01	-.0197
129	FEF2 AQ	.0	8.87766D-22	-19.0517	8.88130D-22	-19.0515	1.00041D+00	.0002
130	FEF3 -1.0	-1.0	8.06730D-17	-16.0973	7.70954D-17	-16.1171	9.55637D-01	-.0197

136	MNCL +	1.0	3.73460D-10	-9.4278	3.56892D-10	-9.4475	9.55637D-01	-.0197
137	MNCL2 AQ	.0	5.16730D-15	-14.2867	5.16943D-15	-14.2866	1.00041D+00	.0002
138	MNCL3 -	-1.0	1.30033D-19	-18.8859	1.24265D-19	-18.9057	9.55637D-01	-.0197
139	MNOH +	1.0	3.33347D-11	-10.4771	3.18558D-11	-10.4968	9.55637D-01	-.0197
140	MN(OH)3	-1.0	8.52626D-21	-20.0692	8.14801D-21	-20.0889	9.55637D-01	-.0197
141	MNF +	1.0	9.00570D-12	-11.0455	8.60618D-12	-11.0652	9.55637D-01	-.0197
142	MNSO4 AQ	.0	7.35106D-08	-7.1337	7.35409D-08	-7.1335	1.00041D+00	.0002
144	MNHCO3 +	1.0	3.34065D-09	-8.4762	3.19245D-09	-8.4959	9.55637D-01	-.0197
162	ZNCL +	1.0	2.34718D-11	-10.6295	2.24305D-11	-10.6492	9.55637D-01	-.0197
163	ZNCL2 AQ	.0	1.12309D-15	-14.9496	1.12355D-15	-14.9494	1.00041D+00	.0002
164	ZNCL3 -	-1.0	5.98149D-20	-19.2223	5.71613D-20	-19.2429	9.55637D-01	-.0197
165	ZNCL4 2-	-2.0	1.47523D-24	-23.83[illegible]	1.23036D-24	-23.9100	8.34011D-01	-.0788
166	ZNF +	1.0	3.97857D-12	-11.4003	3.80207D-12	-11.4200	9.55637D-01	-.0197
167	ZNOH +	1.0	4.91982D-10	-9.3081	4.70156D-10	-9.3278	9.55637D-01	-.0197
168	ZN(OH)2	.0	1.23698D-11	-10.9076	1.23749D-11	-10.9075	1.00041D+00	.0002
169	ZN(OH)3	-1.0	7.56070D-17	-16.1214	7.22529D-17	-16.1411	9.55637D-01	-.0197
170	ZN(OH)4	-2.0	1.02842D-23	-22.9878	8.57717D-24	-23.0667	8.34011D-01	-.0788
171	ZNOHCL A	.0	6.14902D-12	-11.2112	6.15156D-12	-11.2110	1.00041D+00	.0002
174	ZNSO4 AQ	.0	3.33261D-08	-7.4772	3.33398D-08	-7.4770	1.00041D+00	.0002
175	ZN(SO4)2	-2.0	1.36182D-10	-9.8659	1.13577D-10	-9.9447	8.34011D-01	-.0788
180	ZNHCO3 +	1.0	3.28452D-19	-18.4835	3.13881D-19	-18.5032	9.55637D-01	-.0197
181	ZNCO3 AQ	.0	3.36824D-09	-8.4726	3.36963D-09	-8.4724	1.00041D+00	.0002
182	ZN(CO3)2	-2.0	2.83608D-12	-11.5473	2.36532D-12	-11.6261	8.34011D-01	-.0788
183	CDCL +	1.0	2.32584D-11	-10.6334	2.22265D-11	-10.6531	9.55637D-01	-.0197
184	CDCL2 AQ	.0	4.47127D-15	-14.3496	4.47312D-15	-14.3494	1.00041D+00	.0002
185	CDCL3 -	-1.0	1.04409D-19	-18.9804	9.99683D-20	-19.0001	9.55637D-01	-.0197
186	CDF +	1.0	4.62418D-14	-13.3350	4.41903D-14	-13.3547	9.55637D-01	-.0197
187	CDF2 AQ	.0	8.15316D-20	-19.0887	8.15653D-20	-19.0885	1.00041D+00	.0002
188	CD(CO3)3	-4.0	5.79944D-25	-24.2366	2.80591D-25	-24.5519	4.83824D-01	-.3153
189	CDOH +	1.0	3.79910D-13	-12.4203	3.63054D-13	-12.4400	9.55637D-01	-.0197
190	CD(OH)2	.0	9.78546D-16	-15.0094	9.78951D-16	-15.0092	1.00041D+00	.0002
191	CD(OH)3	-1.0	7.78530D-22	-21.1087	7.43992D-22	-21.1284	9.55637D-01	-.0197
192	CD(OH)4	-2.0	5.38522D-29	-28.2688	4.49133D-29	-28.3476	8.34011D-01	-.0788
193	CDZO+ +3	3.0	1.78915D-20	-19.7473	1.18933D-20	-19.9247	6.64717D-01	-.1774
194	CDO-CL A	.0	3.45510D-14	-13.4545	3.45457D-14	-13.4544	1.00041D+00	.0002
195	CDNO3 +	1.0	1.10035D-21	-20.9584	1.09179D-21	-20.9781	9.55637D-01	-.0197
196	CDSO4 AQ	.0	3.97425D-10	-9.4007	3.97588D-10	-9.4006	1.00041D+00	.0002
205	CDHCO3 +	1.0	6.06401D-11	-10.2157	5.81621D-11	-10.2354	9.55637D-01	-.0197
206	CDCO3 AQ	.0	3.52877D-11	-10.4557	3.53055D-11	-10.4555	1.00041D+00	.0002
207	CD(SO4)2	-2.0	2.09891D-12	-11.6791	1.75051D-12	-11.7568	8.34011D-01	-.0788
265	HCASO3 +	-1.0	6.47549D-22	-21.1887	6.18821D-22	-21.2084	9.55637D-01	-.0197
266	HASO3 2-	-2.0	1.23566D-27	-26.9081	1.03055D-27	-26.9869	8.34011D-01	-.0788
268	H4ASO3 +	1.0	3.22325D-26	-25.4917	3.08026D-26	-25.5114	9.55637D-01	-.0197
269	HCASO4 -	-1.0	2.94465D-08	-7.5310	2.81403D-08	-7.5507	9.55637D-01	-.0197
270	HASO4 2-	-2.0	3.54679D-08	-7.4502	2.95607D-08	-7.5290	8.34011D-01	-.0788
271	ASO4 -3	-3.0	3.92918D-13	-12.4057	2.61179D-13	-12.5831	6.64717D-01	-.1774
272	HCO3 -	-1.0	2.12542D-04	-3.6726	2.03113D-04	-3.6923	9.55637D-01	-.0197
273	H2CO3 AQ	.0	1.11852D-04	-3.9514	1.11896D-04	-3.9512	1.00041D+00	.0002
274	HSO4 -	-1.0	2.64839D-09	-8.5770	2.53090D-09	-8.5967	9.55637D-01	-.0197
275	HF AQ	.0	9.42758D-11	-10.0256	9.43147D-11	-10.0254	1.00041D+00	.0002
276	HF2 -	-1.0	2.33387D-16	-15.6319	2.23033D-16	-15.6516	9.55637D-01	-.0197
277	H2F2 AQ	.0	6.89514D-20	-19.1615	6.89796D-20	-19.1613	1.00041D+00	.0002
284	U(OH)2 +	2.0	4.58927D-29	-28.3383	3.82751D-29	-28.4171	8.34011D-01	-.0788
285	U(OH)3 +	1.0	2.76707D-25	-24.5580	2.64431D-25	-24.5777	9.55637D-01	-.0197
286	U(OH)4 A	.0	3.54390D-22	-21.4505	3.54536D-22	-21.4503	1.00041D+00	.0002
287	U(OH)5 -	-1.0	3.90146D-20	-19.4088	3.72838D-20	-19.4285	9.55637D-01	-.0197
301	UO2O+ +1	1.0	1.48634D-08	-7.8279	1.42041D-08	-7.8476	9.55637D-01	-.0197
302	UO2)2O+	1.0	3.94417D-11	-10.4038	3.29115D-11	-10.4827	8.34011D-01	-.0788
303	UO2)3O+5	1.0	1.53347D-10	-9.8147	1.46540D-10	-9.8340	9.55637D-01	-.0197
304	UO2O2 A	.0	5.11799D-07	-6.2909	5.12010D-07	-6.2907	1.00041D+00	.0002
305	UO2CO3	-2.0	9.24803D-08	-7.0340	7.71295D-08	-7.1129	8.34011D-01	-.0788
306	UO2(CO3)3	-4.0	8.34416D-10	-9.0784	4.03910D-10	-9.3934	4.83824D-01	-.3153
307	UO2+ +1	1.0	1.29071D-10	-9.8892	1.23345D-10	-9.9088	9.55637D-01	-.0197
308	UO2F AQ	.0	6.33878D-17	-16.1980	6.34179D-17	-16.1978	1.00041D+00	.0002

312	U02S04 A	.0	1.29599D-10	-9.8874	1.29652D-10	-9.8872	1.00041D+00	.0002
313	U02S04)2	-2.0	1.39754D-12	-11.8546	1.16556D-12	-11.9335	8.34011D-01	-.0788

STEP NUMBER 3

.025 = FRACTION OF SOLUTION 1. .975 = FRACTION OF SOLUTION 2.

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	8.1144320-08	-7.0907
C	4.0689350-04	-3.3905
CA	3.5317350-04	-3.4520
CD	7.8138270-09	-8.1071
CL	6.9788470-05	-4.1562
F	9.6419660-07	-6.0158
FE	9.4358100-08	-7.0252
K	1.2738590-05	-4.8949
MG	8.1745570-05	-4.0875
MN	2.5761190-06	-5.5890
N	2.0235020-06	-5.6939
NA	4.0603880-04	-3.3914
S	5.3001960-04	-3.2757
U	7.7781570-07	-6.1091
ZN	8.1763850-07	-6.0874
MO	5.1147770-07	-6.2912

---- LOGK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-22.6852	-14.9666	-7.7185
UO2 (AM	-22.6852	-8.8232	-13.8620
U4O9 (C)	-83.3203	-47.6670	-35.6530
U3O8 (C)	-13.2146	-5.4967	-7.5179
UF4 (C)	-74.1520	-28.8487	-45.3033
UF4.2.5H	-74.1520	-39.0317	-35.1204
UO3 (C)	4.7353	8.9998	-4.2645
GUMMITE	4.7353	11.9242	-7.1890
B-UO2(OH	4.7357	6.4495	-1.7143
SCHOEPIT	4.7352	6.1982	-1.4630
RUTHERFO	-16.3113	-14.4654	-1.8459
ANHYDRIT	-6.9433	-4.3903	-2.5530
ARAGONIT	-10.9523	-8.1420	-2.8103
AFTINITE	-2.1235	11.5038	-13.6273
BRUCITE	9.4616	18.5017	-9.0401
CALCITE	-10.9523	-8.3933	-2.5590
DOLOMITE	-22.5373	-16.4509	-6.0864
FERRITE	-7.5761	-2.3268	-5.2492
FERRIHYD	19.9455	18.5814	1.3630
FE3(OH)8	46.1267	47.6149	-1.4882
FE(OH)3	16.4477	10.4524	5.9913
FE3PO4	-120.4840	-41.5638	-78.9201
FE2(SO4)	-11.3016	34.8911	-46.1926
FLUORITE	-15.6794	-11.2323	-4.3471

GYPSUM	-6.9433	-4.8672	-2.0761
HALITE	-7.5923	1.5191	-9.1113
HEMATITE	39.8910	25.4284	14.4625
HUNTITE	-45.7073	-28.2636	-17.4437
HYDRMAGN	-36.8784	-5.3115	-31.5670
JAROSITE	25.7613	32.6406	-6.8792
MACKINAW	-120.4840	-42.2938	-78.1901
MAGHEMIT	39.8910	33.7749	6.1161
MAGNESIT	-11.5850	-7.6213	-3.9637
MAGNETIT	46.1263	34.4675	11.6588
MELANTER	-10.8024	-2.6595	-8.1429
MIRABILI	-10.2107	-2.3679	-7.8427
NATRON	-14.2197	-2.3527	-11.8671
NESQUEHO	-11.5850	-5.2365	-6.3486
PYRITE	-219.7828	-94.5162	-125.2665
SIDERITE	-14.8113	-10.1969	-4.6144
THENARDI	-10.2106	-.1422	-10.0683
THERMONA	-14.2196	.3155	-14.5351
PYROLUSI	35.3791	45.0094	-9.6302
BIRNESSI	35.3791	45.3064	-9.9273
NSUTITE	35.3791	44.7164	-9.3373
BIXBYITE	43.3378	54.8224	-11.4845
HAUSMANN	51.2965	66.8487	-15.5522
PYROCROI	7.9587	16.5864	-8.6277
MANGANIT	21.6689	26.9764	-5.3075
RHODOCHR	-13.0879	-10.2722	-2.8157
MN(OH)2	-14.0529	1.5567	-15.6116
MNS GREE	-118.7605	-33.4603	-85.3002
MNS(A)	-9.0765	3.6954	-12.7743
MNSO4	-7.7745	51.3003	-59.0751
ZN METAL	-19.9707	28.1964	-48.1671
ZNCL2	-14.5616	6.1879	-22.7497
SMITHSON	-13.5969	-9.7112	-3.8857
ZNCO3 1	-13.5968	-10.2620	-3.3348
ZNF2	-18.2877	-.6535	-17.6342
ZN(OH)2	7.4497	11.5000	-4.0503
ZN(OH)F	3.8977	15.2000	-11.3023
ZNF(OH)	15.0371	38.5000	-23.2629
ZNO(OH)2	-2.1391	7.5000	-9.6391
ZNO(OH)A	10.7614	26.4000	-15.6386
ZNK(SO4)2	-33.9043	3.0750	-36.9793
ZNO(A)	7.4497	11.3100	-3.8603
ZINCITE	7.4497	12.5681	-5.1183
ZN3(PO4)	-11.7259	23.1270	-34.8529
ZNS (A)	-119.2695	-46.9369	-72.3325
SPHALERI	-119.2695	-49.8103	-69.4592
WURTZITE	-119.2695	-47.6590	-71.6105
ZINCOSIT	-9.5676	4.2819	-13.8497
ZNSO4 1	-9.5876	.1348	-9.7224
BIANCHIT	-9.5879	-1.7494	-7.8385
GOSLARIT	-9.5879	-2.1786	-7.4093
CD METAL	-22.0053	14.6824	-36.6877
GAMMA CD	-22.0053	14.7916	-36.7969
OTAVITE	-15.6314	-13.7016	-1.9299
CDCL2	-16.5964	-.3839	-16.2125
CDCL2 1	-16.5964	-1.5994	-15.0970
CDCL2(A)	-16.5969	-2.0577	-14.5392
CDF2	-20.3167	-2.3541	-17.9626
CD(OH)2	5.4151	13.6577	-8.2426
CDO(A)	-5.5907	4.2179	-9.8086
CDS(O)	-.7507	21.5477	-22.3025
CDS(A)	-17.8287	6.7102	-24.5389
CD4(OH)6	4.6009	28.4000	-23.7991
[illegible]	5.4151	16.7000	-11.2849

CDSO4,2.	-11.6224	-1.5852	-10.0373
GREENOCK	-121.3041	-54.6576	-66.6465
ARSENOLI	-158.2973	-89.4824	-68.8150
CLAUDETI	-158.2973	-89.6735	-68.6239
ORIPMENT	-459.3064	-222.2589	-237.0475
REALGAR	-180.0038	-80.8455	-99.1583
AS2O5	-24.3078	7.0584	-31.3662
SULFUR	-99.2988	-39.4756	-59.8232
CA3(ASO4	5.9750	22.3000	-16.3250
FEASO4.2	7.7915	14.0924	-6.3009
MN3ASO42	-.4318	12.5000	-12.9318
ZN3ASO42	-1.9586	13.6500	-15.6086
LIME	10.0943	35.8644	-25.7701
PORTLAND	10.0943	24.7030	-14.6087
WUSTITE	7.3581	13.3361	-5.9780
PERICLAS	9.4616	23.9033	-14.4418
MAG-FERR	49.3526	48.5693	.7833
LEPIDOCR	19.9455	15.0624	4.8831
FE(OH)3S	19.9455	16.3624	3.5830
NA2SO3	-37.6310	5.1461	-42.7771
K2SO3	-40.6388	8.3544	-48.9932
CASO3.2H	-34.3637	-3.6820	-30.6817
CASO3.5H	-34.3637	-3.1135	-31.2502
MGSO3	-34.9964	7.7195	-42.7159
CH4(GAS)	-130.7083	-45.1206	-85.6075
CO2(GAS)	-21.0466	-18.1941	-2.8515
O2(GAS)	54.8408	92.1707	-37.3299
CAMOC.	-9.9350	-7.7664	-2.1726

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AE	8.1144720-05	-7.0907
C	4.0685350-04	-3.3905
CA	3.5317750-04	-3.4570
CL	7.8194170-05	-6.1071
CU	6.9786470-05	-4.1562
F	9.6419660-07	-6.0156
FE	9.4756170-[illegible]	-7.0252
K	1.2736590-05	-4.8949
MG	8.1745570-05	-4.0875
MN	2.5761190-06	-5.5890
N	2.0235020-06	-5.6939
NA	4.0603880-04	-3.3914
S	5.3001960-04	-3.2757
U	7.7781570-07	-6.1091
ZN	8.1763860-07	-6.0874
MO	5.1147770-07	-6.2912

Input concentrations for Equilibration Calcs: Attachments B-2 & B-3

----DESCRIPTION OF SOLUTION----

PH = 6.8774
PE = 6.8575
ACTIVITY H2O = 1.0000
IONIC STRENGTH = .0000
TEMPERATURE = .2575
ELECTRICAL BALANCE = -1.0768E-04

ITERATIONS = 129

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.56463D-07	-6.8056	1.48794D-07	-6.8274	9.50984D-01	-.0218
2	E-	-1.0	1.30977D-07	-6.8828	1.30977D-07	-6.8828	1.00000D+00	.0000
3	H2O	.0	9.99969D-01	-.0000	9.99969D-01	-.0000	1.00000D+00	.0000
6	H3ASO4	.0	7.01202D-13	-12.1542	7.01561D-13	-12.1539	1.00051D+00	.0002
10	CO3 2-	-2.0	4.96074D-08	-7.3045	4.05732D-08	-7.3918	8.17887D-01	-.0873
11	CA 2+	2.0	3.34264D-04	-3.4759	2.75087D-04	-3.5605	8.22963D-01	-.0846
12	CD 2+	2.0	7.04081D-09	-8.1524	5.75859D-09	-8.2397	8.17887D-01	-.0873
13	CL-	-1.0	6.97878D-05	-4.1562	6.63182D-05	-4.1784	9.50283D-01	-.0221
16	F-	-1.0	9.60559D-07	-6.0175	9.13476D-07	-6.0393	9.50984D-01	-.0218
17	FE 2+	2.0	4.65340D-08	-7.3322	3.80596D-08	-7.4195	8.17887D-01	-.0873
19	K+	1.0	1.27155D-05	-4.8957	1.20833D-05	-4.9178	9.50283D-01	-.0221
21	MG 2+	2.0	7.77541D-05	-4.1093	6.40875D-05	-4.1932	8.24234D-01	-.0839
22	MN 2+	2.0	2.46147D-06	-5.6088	2.01320D-06	-5.6961	8.17887D-01	-.0873
23	NO3 -	-1.0	1.48680D-14	-13.8277	1.41393D-14	-13.8496	9.50984D-01	-.0218
24	NA+	1.0	4.05301D-04	-3.3922	3.85553D-04	-3.4139	9.51276D-01	-.0217
29	SO4 2-	-2.0	5.06758D-04	-3.2952	4.14259D-04	-3.3827	8.17468D-01	-.0875
32	UO2 2+	2.0	1.47147D-09	-8.8322	1.20350D-09	-8.9196	8.17887D-01	-.0873
34	ZN 2+	2.0	7.62484D-07	-6.1178	6.23626D-07	-6.2051	8.17887D-01	-.0873
35	MOO4 2-	-2.0	5.11478D-07	-6.2912	4.18331D-07	-6.3785	8.17887D-01	-.0873
51	H3ASO3	.0	7.20604D-19	-18.1423	7.20973D-19	-18.1421	1.00051D+00	.0000
53	FE 3+	3.0	9.23169D-15	-14.0347	5.87275D-15	-14.2312	6.36151D-01	-.1964
54	MN 3+	3.0	1.47815D-26	-25.8303	9.40327D-27	-26.0267	6.36151D-01	-.1964
55	NH4 +	1.0	2.01260D-06	-5.6962	1.91395D-06	-5.7181	9.50984D-01	-.0218
56	NO2 -	-1.0	1.66193D-10	-9.7794	1.58347D-10	-9.8012	9.50984D-01	-.0218
61	UO2 +	1.0	1.67136D-13	-12.7769	1.58543D-13	-12.7988	9.50984D-01	-.0218
65	OH-	-1.0	9.27294D-09	-8.0326	8.81842D-09	-8.0546	9.50984D-01	-.0218
75	NH4SO4 -	-1.0	1.07430D-08	-7.9690	1.02141D-08	-7.9908	9.50984D-01	-.0218
76	MGOH +	1.0	7.25580D-11	-10.1391	6.90396D-11	-10.1609	9.50984D-01	-.0218
77	MGF +	1.0	1.99379D-09	-8.7003	1.89626D-09	-8.7221	9.50984D-01	-.0218
78	MGCO3 AQ	.0	1.69700D-09	-8.7703	1.69788D-09	-8.7721	1.00051D+00	.0000
79	MGHCO3 +	1.0	1.75776D-07	-6.7550	1.67160D-07	-6.7768	9.50984D-01	-.0218
80	MGSO4 AQ	.0	3.81197D-06	-5.4189	3.81392D-06	-5.4186	1.00051D+00	.0000
84	CAOH +	1.0	5.34391D-11	-10.2721	5.08196D-11	-10.2940	9.50984D-01	-.0218
85	CAHCO3 +	1.0	3.55105D-07	-6.4496	3.37700D-07	-6.4715	9.50984D-01	-.0218
86	CACO3 AQ	.0	1.14543D-08	-7.9410	1.14603D-08	-7.9408	1.00051D+00	.0000
87	CASO4 AQ	.0	1.85414D-05	-4.7319	1.85509D-05	-4.7316	1.00051D+00	.0000
91	CAF +	1.0	1.28945D-09	-8.8896	1.22625D-09	-8.9114	9.50984D-01	-.0218
92	NACO3 -	-1.0	7.83181D-11	-10.1061	7.44793D-11	-10.1280	9.50984D-01	-.0218
93	NAHCO3 A	.0	2.79697D-05	-7.5533	2.79840D-05	-7.5531	1.00051D+00	.0000
94	NASO4 -	-1.0	7.09563D-07	-6.1490	6.74783D-07	-6.1708	9.50984D-01	-.0218
96	NAF AQ	.0	5.70899D-11	-10.2434	5.71191D-11	-10.2432	1.00051D+00	.0000
97	KSO4 -	-1.0	2.31165D-08	-7.6361	2.19835D-08	-7.6579	9.50984D-01	-.0218
109	FEOH +	1.0	1.13594D-11	-10.9446	1.08026D-11	-10.9665	9.50984D-01	-.0218
110	FEOH3 -1	-1.0	1.19492D-20	-19.9227	1.13635D-20	-19.9445	9.50984D-01	-.0218
111	FESO4 AQ	.0	1.71218D-09	-8.7665	1.71306D-09	-8.7662	1.00051D+00	.0000
113	FEOH2 AQ	.0	5.92678D-17	-16.2272	5.92982D-17	-16.2270	1.00051D+00	.0000
117	FEOH 2+	2.0	6.37806D-11	-10.1953	5.21654D-11	-10.2826	8.17887D-01	-.0873
118	FESO4 +	1.0	1.17201D-14	-13.9311	1.11456D-14	-13.9529	9.50984D-01	-.0218
121	FEO2 2+	2.0	6.12095D-18	-17.2130	5.00627D-18	-17.3000	8.17887D-01	-.0873
121	FEO2 +	1.0	3.66361D-21	-20.4361	3.48403D-21	-20.4579	9.50984D-01	-.0218
122	FEO2 AQ	.0	2.30949D-26	-25.6365	2.31068D-26	-25.6363	1.00051D+00	.0000
123	FEO4 -	-1.0	4.52663D-08	-7.3440	4.30665D-08	-7.3659	9.50984D-01	-.0218
124	FEO3 AQ	.0	7.28224D-10	-9.1377	7.28557D-10	-9.1375	1.00051D+00	.0000
125	FEO4 -	-1.0	2.22526D-11	-10.6516	2.11618D-11	-10.6744	9.50984D-01	-.0218
127	FE 3+	3.0	6.87157D-15	-14.1623	5.62217D-15	-14.2503	8.17887D-01	-.0873

130	FE(SO4)2	-1.0	1.38196D-16	-15.8595	1.31422D-16	-15.8813	9.50984D-01	-.0218
131	FE2(OH)2	4.0	4.98232D-19	-18.3026	2.22949D-19	-18.6518	4.47480D-01	-.3492
132	FE3(OH)4	5.0	8.21334D-23	-22.0855	2.33805D-23	-22.6311	2.84665D-01	-.5457
136	MNCL +	1.0	5.67998D-10	-9.2457	5.40158D-10	-9.2675	9.50984D-01	-.0218
137	MNCL2 AQ	.0	9.72592D-15	-14.0121	9.73090D-15	-14.0118	1.00051D+00	.0002
138	MNCL3 -	-1.0	3.05923D-19	-18.5144	2.90928D-19	-18.5362	9.50984D-01	-.0218
139	MNOH +	1.0	4.06711D-11	-10.3907	3.86775D-11	-10.4125	9.50984D-01	-.0218
140	MN(OH)3	-1.0	1.01839D-20	-19.9921	9.68476D-21	-20.0139	9.50984D-01	-.0218
141	MNF +	1.0	1.36903D-11	-10.8636	1.30192D-11	-10.8854	9.50984D-01	-.0218
142	MNSO4 AQ	.0	1.08941D-07	-6.9628	1.08997D-07	-6.9626	1.00051D+00	.0002
144	MNHCO3 +	1.0	5.08793D-09	-8.2935	4.83854D-09	-8.3153	9.50984D-01	-.0218
162	ZNCL +	1.0	3.56741D-11	-10.4476	3.39255D-11	-10.4695	9.50984D-01	-.0218
163	ZNCL2 AQ	.0	2.11302D-15	-14.6751	2.11410D-15	-14.6749	1.00051D+00	.0002
164	ZNCL3 -	-1.0	1.40724D-19	-18.8516	1.33826D-19	-18.8735	9.50984D-01	-.0218
165	ZNCL4 2-	-2.0	4.38270D-24	-23.3583	3.58455D-24	-23.4456	8.17887D-01	-.0873
166	ZNF +	1.0	6.03100D-12	-11.2196	5.73538D-12	-11.2414	9.50984D-01	-.0218
167	ZNOH +	1.0	5.97812D-10	-9.2234	5.68510D-10	-9.2453	9.50984D-01	-.0218
168	ZN(OH)2	.0	1.48818D-11	-10.8273	1.48894D-11	-10.8271	1.00051D+00	.0002
169	ZN(OH)3	-1.0	9.09994D-17	-16.0410	8.65390D-17	-16.0628	9.50984D-01	-.0218
170	ZN(OH)4	-2.0	1.25321D-23	-22.9020	1.02498D-23	-22.9893	8.17887D-01	-.0873
171	ZNOHCL A	.0	9.19887D-12	-11.0363	9.20356D-12	-11.0360	1.00051D+00	.0002
174	ZNSO4 AQ	.0	4.91907D-08	-7.3081	4.92159D-08	-7.3079	1.00051D+00	.0002
175	ZN(SO4)2	-2.0	2.49330D-10	-9.6032	2.03924D-10	-9.6905	8.17887D-01	-.0873
180	ZNHCO3 +	1.0	4.98399D-19	-18.3024	4.73969D-19	-18.3242	9.50984D-01	-.0218
181	ZNCO3 AQ	.0	5.04594D-09	-8.2971	5.04852D-09	-8.2968	1.00051D+00	.0002
182	ZN(CO3)2	-2.0	5.35439D-12	-11.2713	4.37929D-12	-11.3586	8.17887D-01	-.0873
183	CDCL +	1.0	3.50503D-11	-10.4553	3.33323D-11	-10.4771	9.50984D-01	-.0218
184	CDCL2 AQ	.0	8.34100D-15	-14.0788	8.34527D-15	-14.0786	1.00051D+00	.0002
185	CDCL3 -	-1.0	2.44174D-19	-18.6123	2.32203D-19	-18.63[illegible]	[illegible]9984D-01	-.0218
186	CDF +	1.0	6.96370D-14	-13.1572	6.62237D-14	-13.17[illegible]	[illegible]0984D-01	-.0218
187	CDF2 AQ	.0	1.51876D-19	-18.8185	1.51953D-19	-18.818[illegible]	[illegible]00051D+00	.0002
188	CD(CO3)3	-4.0	1.42647D-24	-23.8457	6.36315D-25	-24.1950	4.47480D-01	-.3492
189	CDOH +	1.0	4.58946D-13	-12.3380	4.36450D-13	-12.3601	9.50984D-01	-.0218
190	CD(OH)2	.0	1.16116D-15	-14.9351	1.16176D-15	-14.9349	1.00051D+00	.0002
191	CD(OH)3	-1.0	9.21178D-22	-21.0357	8.74026D-22	-21.0585	9.50984D-01	-.0218
192	CD(OH)4	-2.0	6.41541D-29	-28.1928	5.24705D-29	-28.[illegible]	8.17887D-01	-.0873
193	CD2OH +3	3.0	2.70702D-20	-19.5675	1.72208D-20	-19.7639	6.36151D-01	-.1964
194	CDHCL 4	.0	5.20762D-14	-13.2834	5.21029D-14	-13.2831	1.00051D+00	.0002
195	CDNO3 +	1.0	4.74277D-22	-21.3240	4.51039D-22	-21.3458	9.50984D-01	-.0218
196	CDSO4 AQ	.0	5.83708D-10	-9.2342	5.83506D-10	-9.2340	1.00051D+00	.0002
205	CD(CO3) +	1.0	9.18266D-11	-10.0373	8.73256D-11	-10.0589	9.50984D-01	-.0218
206	CDCO3 AQ	.0	5.85279D-11	-10.2327	5.85329D-11	-10.2324	1.00051D+00	.0002
207	CD(SO4)2	-2.0	3.82209D-12	-11.4178	3.12507D-12	-11.5051	8.17887D-01	-.0873
265	H2ASO3 -	-1.0	1.10617D-21	-20.9564	1.05365D-21	-20.9772	9.50984D-01	-.0218
266	HASO3 2-	-2.0	2.13536D-27	-26.6705	1.74649D-27	-26.7578	8.17887D-01	-.0873
268	H4ASO3 +	1.0	5.58897D-26	-25.2527	5.31502D-26	-25.2745	9.50984D-01	-.0218
269	H2ASO4 -	-1.0	3.66654D-08	-7.4357	3.48682D-08	-7.4576	9.50984D-01	-.0218
270	HASO4 2-	-2.0	4.44777D-08	-7.3519	3.63778D-08	-7.4392	8.17887D-01	-.0873
271	ASO4 -3	-3.0	5.01603D-13	-12.2995	3.19223D-13	-12.4959	6.36151D-01	-.1964
272	HCO3 -	-1.0	2.65482D-04	-3.5762	2.52469D-04	-3.5978	9.50984D-01	-.0218
273	H2CO3 AQ	.0	1.39875D-04	-3.8543	1.39946D-04	-3.8540	1.00051D+00	.0002
274	HSO4 -	-1.0	3.26584D-09	-8.4854	3.10662D-09	-8.5074	9.50984D-01	-.0218
275	HF AQ	.0	1.18266D-10	-9.9271	1.18327D-10	-9.9269	1.00051D+00	.0002
276	HF2 -	-1.0	3.65934D-16	-15.4366	3.47998D-16	-15.4584	9.50984D-01	-.0218
277	H2F2 AQ	.0	1.08229D-19	-18.9657	1.08285D-19	-18.9654	1.00051D+00	.0002
284	U(OH)3 +	2.0	6.30333D-29	-28.2004	5.15541D-29	-28.2877	8.17887D-01	-.0873
285	U(OH)4 +	1.0	3.72317D-25	-24.4291	3.54063D-25	-24.4575	9.50984D-01	-.0218
286	UO2+ + A	.0	4.71145D-22	-21.3268	4.71386D-22	-21.3266	1.00051D+00	.0002
287	UO2+ + -	-1.0	5.17762D-20	-19.2859	4.92364D-20	-19.3077	9.50984D-01	-.0218
301	UO2(OH)2	1.0	1.45805D-08	-7.8371	1.38780D-08	-7.8589	9.50984D-01	-.0218
302	UO2(OH)3	2.0	3.80487D-11	-10.4197	3.11192D-11	-10.5070	8.17887D-01	-.0873
303	UO2(OH)4	1.0	1.47000D-10	-9.8329	1.33136D-10	-9.8757	9.50984D-01	-.0218
304	UO2(CO3) A	.0	6.18281D-07	-6.2089	6.18602D-07	-6.2086	1.00051D+00	.0002
305	UO2(CO3)2	-2.0	1.41275D-07	-6.8507	1.15351D-07	-6.9387	8.17887D-01	-.0873

308	UO2F2 AQ	.0	9.57714D-13	-12.0188	9.58204D-13	-12.0185	1.00051D+00	.0002
309	UO2F3 -1	-1.0	2.53904D-16	-15.5953	2.41459D-16	-15.6172	9.50984D-01	-.0218
310	UO2F4 2-	-2.0	4.90240D-21	-20.3096	4.00961D-21	-20.3969	8.17887D-01	-.0873
311	UO2CL +1	1.0	1.15406D-13	-12.9378	1.09749D-13	-12.9596	9.50984D-01	-.0218
312	UO2SO4 A	.0	1.54363D-10	-9.8115	1.54442D-10	-9.8112	1.00051D+00	.0002
313	UO2SO4)2	-2.0	2.06646D-12	-11.6848	1.69013D-12	-11.7721	8.17887D-01	-.0873

STEP NUMBER 4

.030 = FRACTION OF SOLUTION 1. .970 = FRACTION OF SOLUTION 2.

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	9.737318D-08	-7.0116
C	4.882721D-04	-3.3113
CA	4.238062D-04	-3.3728
CD	9.376592D-09	-8.0283
CL	6.374616D-05	-4.0770
F	1.157036D-06	-5.9367
FE	1.132297D-07	-6.9460
K	1.528630D-05	-4.8157
MG	9.809468D-05	-4.0084
MN	3.091343D-06	-5.5099
N	2.475103D-04	-5.6147
NA	4.872465D-04	-3.3123
S	6.360236D-04	-3.1965
U	9.373768D-07	-6.0299
ZN	9.811665D-07	-6.0083
MO	6.137733D-07	-6.2109

---- LOGK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINITE	-22.5864	-14.9640	-7.6224
UO2 (AM	-22.5864	-8.8218	-13.7646
U409 (C)	-63.0409	-42.6611	-20.3799
U308 (C)	-13.1497	-5.6989	-7.4509
UF4 (C)	-73.7327	-28.8461	-44.8866
UF4.2.5H	-73.7328	-39.0260	-34.7068
UO3 (C)	4.7183	8.9966	-4.2782
GUMMITE	4.7183	11.9204	-7.2020
B-UO2(OH	4.7183	6.4472	-1.7289
SCHOEPITE	4.7183	6.1960	-1.4779
RUTHERFO	-16.2473	-14.4650	-1.7823
ANHYDRITE	-6.5160	-4.3509	-2.4151
ARAGONITE	-10.8285	-8.1620	-2.6665
APATITE	-1.5118	11.4882	-12.6188
BR[illegible]	9.8[illegible]	18.4[illegible]	-8.8[illegible]
CA[illegible]	-10.8285	-8.3977	-2.4307
[illegible]OMITE	-[illegible]	-16.4[illegible]	-5.7[illegible]
ERSKINITE	-7.4384	-2.3047	-5.1101
FERRIHYD	19.9811	18.[illegible]	1.[illegible]
FE3(OH)8	46.0978	47.4115	-1.[illegible]
FE(OH)2.7	16.7[illegible]	17.[illegible]	4.[illegible]

FLUORITE	-15.4165	-11.2712	-4.1453
GOETHITE	19.9811	15.1475	4.8336
GREIGITE	-458.4361	-168.1834	-290.2527
GYPSUM	-6.8060	-4.8672	-1.9388
HALITE	-7.4379	1.5192	-8.9571
HEMATITE	39.9622	25.4199	14.5423
HUNTITE	-45.1326	-28.2679	-16.8647
HYDRMAGN	-36.2406	-5.3202	-30.9204
JAROSITE	26.0179	32.6263	-6.6084
MACKINAW	-119.8530	-42.2837	-77.5693
MAGHEMIT	39.9622	33.7715	6.1907
MAGNESIT	-11.4412	-7.6223	-3.8189
MAGNETIT	46.2908	34.4556	11.8352
MELANTER	-10.6341	-2.6590	-7.9751
MIRABILI	-9.9876	-2.3648	-7.6229
NATRON	-13.9906	-2.3500	-11.6406
NESQUEHO	-11.4413	-5.2374	-6.2038
PYRITE	-218.7300	-94.4941	-124.2359
SIDERITE	-14.6369	-10.1978	-4.4391
THENARDI	-9.9875	-.1423	-9.8451
THERMONA	-13.9905	.3150	-14.3055
PYROLUSI	35.3260	45.0001	-9.6742
BIRNESSI	35.3260	45.3021	-9.9761
NSUTITE	35.3260	44.7121	-9.3861
BIXBYITE	43.3477	54.8111	-11.4640
HAUSMANN	51.3664	66.8752	-15.4668
PYROCROI	8.0212	16.5826	-8.5614
MANGANIT	21.6736	26.9721	-5.2985
RHODOCHR	-12.9444	-10.2726	-2.6718
MNCL2:4	-13.6297	1.5616	-15.3914
MNS GREE	-118.1635	-33.4510	-84.7054
MNSO4	-8.9414	3.6925	-12.6343
MNCO3(SOL)	-7.5407	51.2850	-58.8258
ZN METAL	-19.7940	28.1900	-47.9840
ZNCL2	-14.3401	8.1650	-22.5051
SMITHSON	-13.4548	-9.7119	-3.7429
ZNCO3:1	-13.4549	-10.2627	-3.1922
ZNFE	-18.0674	-.6557	-17.4116
ZN(OH)2	7.5107	11.5000	-3.9892
ZN2(OH)3	4.0961	15.2000	-11.1039
ZN5(OH)8	15.7029	38.5030	-22.7971
ZN2(OH)2	-1.9411	7.5000	-9.4411
ZN4(OH)6	13.0804	28.4000	-15.3196
ZNNO3(2)	-34.5579	3.0759	-37.6339
ZNO(ACTI	7.5108	11.3100	-3.7992
ZINCITE	7.5108	12.5644	-5.0736
ZN3(SO4	-11.3930	23.1166	-34.5094
ZNS (A)	-118.6710	-46.9260	-71.7447
SPHALERI	-118.6710	-49.7985	-68.8721
WURTZITE	-118.6710	-47.6481	-71.0229
ZINCOSIT	-9.4519	4.2786	-13.7305
ZNSO4:1	-9.4519	.1330	-9.5849
BIANCHIT	-9.4520	-1.7494	-7.7025
GOSLARIT	-9.4520	-2.1760	-7.2759
CD META	-21.8305	14.6795	-36.5100
GAMMA CD	-21.8305	14.7898	-36.6195
CD(OH)2	-15.4916	-13.7017	-1.7871
CDCL2	-16.3770	-.3646	-15.9124
CDCL2:1	-16.3771	-1.5877	-14.7893
CDCL2:2	-16.3771	-2.0931	-14.3941
CDS	-20.0993	-2.3375	-17.7618
CDCO3	5.4779	13.6900	-8.1740
CDO	-5.4516	4.0046	-9.4562
CDSO4	-5.5010	2.5[illegible]	-8.0[illegible]

MONTEPON	5.4738	16.7560	-11.2822
CDSO4	-11.4888	.8739	-12.3627
CDSO4, 1	-11.4888	-1.1631	-10.3257
CDSO4,2.	-11.4888	-1.5859	-9.9030
GREENOCK	-120.7079	-54.6447	-66.0632
ARSENOLI	-157.5179	-89.4598	-68.0581
CLAUDETI	-157.5179	-89.6511	-67.8668
ORIPMENT	-457.3041	-222.2046	-235.0996
REALGAR	-179.2136	-80.8252	-98.3884
AS2O5	-24.1494	7.0575	-31.2069
SULFUR	-98.8770	-39.4662	-59.4107
CA3(ASO4	6.3205	22.3000	-15.9795
FEASO4.2	7.9063	14.0907	-6.1844
MN3ASO42	-.0859	12.5000	-12.5859
ZN3ASO42	-1.6171	13.6500	-15.2671
LIME	10.1567	35.8566	-25.7000
PORTLAND	10.1566	24.6978	-14.5412
WUSTITE	7.4404	13.3320	-5.8915
PERICLAS	9.5244	23.8973	-14.3729
MAG-FERR	49.4865	48.5547	.9318
LEPIDOCR	19.9811	15.0607	4.9203
FE(OH)3S	19.9811	16.3607	3.6203
NA2SO3	-37.2922	5.1456	-42.4378
K2SO3	-40.3002	8.3540	-48.6543
CASO3.2H	-34.1108	-3.6815	-30.4293
CASO3.5H	-34.1109	-3.1136	-30.9972
MGSO3	-34.7430	7.7164	-42.4595
CH4(GAS)	-130.1647	-45.1136	-85.0742
CO2(GAS)	-20.9656	-18.1950	-2.7706
O2(GAS)	54.6095	92.1473	-37.5362
CAMGO4	-9.7989	-7.7663	-2.0325

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY	mg/L
AS	9.7372180-08	-7.0116	0.0573
C	4.8827210-04	-3.3113	
CA	4.2382620-04	-3.3725	
CD	9.3765900-09	-8.0260	0.0010
CL	5.3746160-05	-4.0770	
F	1.1570360-06	-5.9367	
FE	1.1322970-07	-6.9460	
K	1.5286300-05	-4.8157	
MG	9.8094680-05	-4.0084	
MN	3.0913430-06	-5.5099	
N	2.4282030-06	-5.6147	
NA	4.8724650-04	-3.3123	
S	6.3602360-04	-3.1965	
U	9.3337880-07	-6.0299	0.22
ZN	9.8116650-07	-6.0083	
MO	6.1377330-07	-6.2120	0.0558

----DESCRIPTION OF SOLUTION----

PH = 6.8043
PE = 4.6781
ACTIVITY H2O = 1.0000

ELECTRICAL BALANCE = -1.2079D-04
THOR = 5.7743D-03
TOTAL ALKALINITY = 3.2157D-04
ITERATIONS = 25

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.58267D-07	-6.8006	1.49859D-07	-6.8243	9.46877D-01	-.0237
2	E-	-1.0	1.48567D-07	-6.8281	1.48567D-07	-6.8281	1.00000D+00	.0000
3	H2O	.0	9.99962D-01	-.0000	9.99962D-01	-.0000	1.00000D+00	.0000
6	H3ASO4	.0	8.41424D-13	-12.0750	8.41938D-13	-12.0747	1.00061D+00	.0003
10	CO3 2-	-2.0	5.99575D-08	-7.2222	4.81967D-08	-7.3170	8.03848D-01	-.0948
11	CA 2+	2.0	3.97844D-04	-3.4003	3.22137D-04	-3.4920	8.09707D-01	-.0917
12	CD 2+	2.0	8.31845D-09	-8.0800	6.68677D-09	-8.1748	8.03848D-01	-.0946
13	CL-	-1.0	8.37452D-05	-4.0770	7.92267D-05	-4.1011	9.46045D-01	-.0241
16	F-	-1.0	1.15198D-06	-5.9386	1.09078D-06	-5.9623	9.46877D-01	-.0237
17	FE 2+	2.0	5.95519D-08	-7.2251	4.78707D-08	-7.3199	8.03848D-01	-.0948
19	K+	1.0	1.52538D-05	-4.8166	1.44308D-05	-4.8407	9.46045D-01	-.0241
21	MG 2+	2.0	9.26059D-05	-4.0334	7.51196D-05	-4.1242	8.11177D-01	-.0909
22	MN 2+	2.0	2.93372D-06	-5.5376	2.35826D-06	-5.6274	8.03848D-01	-.0948
23	NO3 -	-1.0	6.51196D-15	-14.1863	6.16607D-15	-14.2100	9.46877D-01	-.0237
24	NA+	1.0	4.86205D-04	-3.3132	4.60545D-04	-3.3367	9.47216D-01	-.0236
29	SO4 2-	-2.0	6.04070D-04	-3.2189	4.85265D-04	-3.3140	8.03331D-01	-.0951
32	UO2 2+	2.0	1.46065D-09	-8.8354	1.17417D-09	-8.9303	8.03848D-01	-.0948
34	ZN 2+	2.0	9.05669D-07	-6.0431	7.28020D-07	-6.1379	8.03848D-01	-.0948
35	MOO4 2-	-2.0	6.13773D-07	-6.2120	4.93380D-07	-6.3068	8.03848D-01	-.0948
51	H3ASO3	.0	1.11551D-15	-17.9525	1.11619D-15	-17.9503	1.00061D+00	.0003
53	FE 3+	3.0	1.06846D-14	-13.9710	6.53733D-15	-14.1846	6.11844D-01	-.2134
54	MN 3+	3.0	1.60305D-26	-25.7951	9.80314D-27	-26.0084	6.11844D-01	-.2134
55	NH4 +	1.0	2.41700D-06	-5.6174	2.28484D-06	-5.6411	9.46877D-01	-.0237
56	NO2 -	-1.0	9.34142D-11	-10.0296	8.84033D-11	-10.0533	9.46877D-01	-.0237
61	UO2 +	1.0	1.85506D-13	-12.7316	1.75670D-13	-12.7553	9.46877D-01	-.0237
65	OH-	-1.0	9.29487D-09	-8.0319	8.80193D-09	-8.0555	9.46877D-01	-.0237
75	NH4SO4 -	-1.0	1.50850D-08	-7.8213	1.42836D-08	-7.8450	9.46877D-01	-.0237
76	MGO +	1.0	8.33541D-11	-10.0685	8.08198D-11	-10.0923	9.46877D-01	-.0237
77	MGF +	1.0	2.87779D-09	-8.5416	2.65863D-09	-8.5753	9.46877D-01	-.0237
78	MGCO3 AQ	.0	2.36475D-09	-8.6260	2.36419D-09	-8.6261	1.00061D+00	.0003
79	MGHCO3 +	1.0	2.47125D-07	-6.6071	2.33997D-07	-6.6315	9.46877D-01	-.0237
80	MGSO4 AQ	.0	5.23640D-06	-5.2810	5.23960D-06	-5.2807	1.00061D+00	.0003
84	CAOH +	1.0	6.27557D-11	-10.2023	5.94219D-11	-10.2261	9.46877D-01	-.0237
85	CAHCO3 +	1.0	4.99554D-07	-6.3014	4.73016D-07	-6.3251	9.46877D-01	-.0237
86	CACO3 AQ	.0	1.59346D-08	-7.7977	1.59444D-08	-7.7974	1.00061D+00	.0003
87	CASO4 AQ	.0	2.54465D-05	-4.5944	2.54621D-05	-4.5941	1.00061D+00	.0003
91	CAF +	1.0	1.81356D-09	-8.7415	1.71722D-09	-8.7652	9.46877D-01	-.0237
92	NACO3 -	-1.0	1.11996D-10	-9.9508	1.06047D-10	-9.9745	9.46877D-01	-.0237
93	NAHCO3 A	.0	3.99675D-05	-7.3983	3.99919D-05	-7.3980	1.00061D+00	.0003
94	NASO4 -	-1.0	9.97601D-07	-6.0010	9.44606D-07	-6.0247	9.46877D-01	-.0237
96	NAF AQ	0	8.14223D-11	-10.0893	8.14721D-11	-10.0890	1.00061D+00	.0003
97	KSO4 -	-1.0	3.25188D-08	-7.4879	3.07913D-08	-7.5116	9.46877D-01	-.0237
109	FEOH +	1.0	1.43205D-11	-10.8440	1.35597D-11	-10.8677	9.46877D-01	-.0237
110	FEOH3 -1	-1.0	1.49491D-20	-19.8254	1.41550D-20	-19.8491	9.46877D-01	-.0237
111	FESO4 AQ	0	2.52560D-09	-8.5976	2.52715D-09	-8.5974	1.00061D+00	.0003
112	FEOH2 AQ	.0	7.47985D-17	-16.1261	7.43442D-17	-16.1284	1.00061D+00	.0003
113	FEOH 2+	2.0	7.00139D-11	-10.1540	5.78880D-11	-10.2374	8.27641D-01	-.0824
115	FEOH4 -	1.0	1.57320D-14	-13.8133	1.45556D-14	-13.8371	9.46877D-01	-.0237
120	FECL 2+	2.0	8.30004D-18	-17.0809	6.67197D-18	-17.1747	8.03848D-01	-.0948
121	FECL +	1.0	5.84568D-21	-20.2330	5.53533D-21	-20.2568	9.46877D-01	-.0237
122	FECL2 AQ	0	4.39076D-24	-23.3583	4.39564D-24	-23.3561	1.00061D+00	.0003
123	FECL3 -	1.0	5.07394D-28	-27.2949	4.80000D-28	-27.3188	9.46877D-01	-.0237

127	FEF 2+	2.0	9.30511D-15	-14.0314	7.47820D-15	-14.1262	[illegible]	[illegible]
128	FEF2 +	1.0	2.49702D-16	-15.6026	2.36437D-16	-15.6263	9.46877D-01	-.0237
129	FEF3 AQ	.0	3.72914D-19	-18.4284	3.73142D-19	-18.4281	1.00061D+00	.0003
130	FE(SO4)2	-1.0	2.12387D-16	-15.6729	2.01104D-16	-15.6966	9.46877D-01	-.0237
131	FE2(OH)2	4.0	6.55692D-19	-18.1833	2.73776D-19	-18.5626	4.17537D-01	-.3793
132	FE3(OH)4	5.0	1.23368D-22	-21.9088	3.15165D-23	-22.5015	2.55467D-01	-.5927
136	MNCL +	1.0	7.98308D-10	-9.0978	7.55899D-10	-9.1215	9.46877D-01	-.0237
137	MNCL2 AQ	.0	1.62581D-14	-13.7889	1.62681D-14	-13.7887	1.00061D+00	.0003
138	MNCL3 -	-1.0	6.13640D-19	-18.2121	5.81042D-19	-18.2358	9.46877D-01	-.0237
139	MNOH +	1.0	4.77738D-11	-10.3208	4.52359D-11	-10.3445	9.46877D-01	-.0237
140	MN(OH)3	-1.0	1.17274D-20	-19.9308	1.11044D-20	-19.9545	9.46877D-01	-.0237
141	MNF +	1.0	1.92325D-11	-10.7160	1.82108D-11	-10.7397	9.46877D-01	-.0237
142	MNSO4 AQ	.0	1.49598D-07	-6.8251	1.49690D-07	-6.8248	1.00061D+00	.0003
144	MNHCO3 +	1.0	7.16142D-09	-8.1450	6.78098D-09	-8.1687	9.46877D-01	-.0237
162	ZNCL +	1.0	5.01187D-11	-10.3000	4.74562D-11	-10.3237	9.46877D-01	-.0237
163	ZNCL2 AQ	.0	3.53172D-15	-14.4520	3.53388D-15	-14.4517	1.00061D+00	.0003
164	ZNCL3 -	-1.0	2.82352D-19	-18.5492	2.67352D-19	-18.5729	9.46877D-01	-.0237
165	ZNCL4 2-	-2.0	1.06482D-23	-22.9727	8.55956D-24	-23.0675	8.03848D-01	-.0948
166	ZNF +	1.0	8.45085D-12	-11.0731	8.00192D-12	-11.0968	9.46877D-01	-.0237
167	ZNOH +	1.0	6.99546D-10	-9.1552	6.62384D-10	-9.1789	9.46877D-01	-.0237
168	ZN(OH)2	.0	1.72634D-11	-10.7629	1.70739D-11	-10.7626	1.00061D+00	.0003
169	ZN(OH)3	-1.0	1.05624D-16	-15.9762	1.00013D-16	-15.9999	9.46877D-01	-.0237
170	ZN(OH)4	-2.0	1.47131D-23	-22.8323	1.18271D-23	-22.9271	8.03848D-01	-.0948
171	ZNOHCL A	.0	1.27365D-11	-10.8949	1.27443D-11	-10.8947	1.00061D+00	.0003
174	ZNSO4 AQ	.0	6.70974D-08	-7.1720	6.73385D-08	-7.1717	1.00061D+00	.0003
175	ZN(SO4)2	-2.0	4.06381D-10	-9.3911	3.26669D-10	-9.4859	8.03848D-01	-.0948
180	ZNHCO3 +	1.0	6.99117D-19	-18.1555	6.61977D-19	-18.1792	9.46877D-01	-.0237
181	ZNCO3 AQ	.0	6.99673D-09	-8.1551	7.00101D-09	-8.1548	1.00061D+00	.0003
182	ZN(CO3)2	-2.0	8.97437D-12	-11.0470	7.21403D-12	-11.1418	8.03848D-01	-.0948
183	CDCL +	1.0	4.86439D-11	-10.3112	4.62492D-11	-10.3349	9.46877D-01	-.0237
184	CDCL2 AQ	.0	1.39051D-14	-13.8592	1.38365D-14	-13.8590	1.00061D+00	.0003
185	CDCL3 -	-1.0	4.84235D-19	-18.3132	4.60405D-19	-18.3369	9.46877D-01	-.0237
186	CDF +	1.0	9.69749D-14	-13.0133	9.18233D-14	-13.0370	9.46877D-01	-.0237
187	CDF2 AQ	.0	2.51434D-19	-18.5996	2.51588D-19	-18.5993	1.00061D+00	.0003
188	CD(CO3)3	-4.0	2.97559D-24	-23.5264	1.24242D-24	-23.9057	4.17537D-01	-.3793
189	CDOH +	1.0	5.34105D-13	-12.2724	5.05753D-13	-12.2961	9.46877D-01	-.0237
190	CD(OH)2	.0	1.37808D-15	-14.8764	1.37955D-15	-14.8762	1.00061D+00	.0003
191	CD(OH)3 -	-1.0	1.05154D-21	-20.9785	9.95680D-22	-21.0019	9.46877D-01	-.0237
192	CD(OH)4	-2.0	7.36607D-29	-28.1325	5.92136D-29	-28.2276	8.03848D-01	-.0948
193	CD2OH +3	3.0	3.78394D-20	-19.4221	2.31518D-20	-19.6354	6.11844D-01	-.2134
194	CDOHCL A	.0	7.18403D-14	-13.1436	7.18642D-14	-13.1434	1.00061D+00	.0003
195	CDNO3 +	1.0	2.40702D-22	-21.6185	2.27934D-22	-21.6420	9.46877D-01	-.0237
196	CDSO4 AQ	.0	7.93547D-10	-9.1004	7.94032D-10	-9.1000	1.00061D+00	.0003
205	CDHCO3 +	1.0	1.28122D-10	-9.8924	1.21315D-10	-9.9161	9.46877D-01	-.0237
206	CDCO3 AQ	.0	8.07176D-11	-10.0930	8.07669D-11	-10.0928	1.00061D+00	.0003
207	CD(SO4)2	-2.0	6.19451D-12	-11.2080	4.97544D-12	-11.3028	8.03848D-01	-.0948
265	H2ASO3 -	-1.0	1.71518D-21	-20.7657	1.62407D-21	-20.7894	9.46877D-01	-.0237
266	HASO3 2-	-2.0	3.33429D-27	-26.4770	2.68026D-27	-26.5718	8.03848D-01	-.0948
268	H4ASO3 +	1.0	8.75240D-26	-25.0579	8.28744D-26	-25.0816	9.46877D-01	-.0237
269	H2ASO4 -	-1.0	4.38501D-08	-7.3580	4.15206D-08	-7.3817	9.46877D-01	-.0237
270	HASO4 2-	-2.0	5.35217D-08	-7.2715	4.30233D-08	-7.3663	8.03848D-01	-.0948
271	ASO4 -3	-3.0	6.13697D-13	-12.2120	3.75487D-13	-12.4254	6.11844D-01	-.2134
272	HCO3 -	-1.0	3.18365D-04	-3.4971	3.01452D-04	-3.5208	9.46877D-01	-.0237
273	H2CO3 AQ	.0	1.67907D-04	-3.7749	1.68010D-04	-3.7747	1.00061D+00	.0003
274	HSO3 -	-1.0	3.87889D-09	-8.4113	3.67283D-09	-8.4350	9.46877D-01	-.0237
275	HF AQ	.0	1.42408D-10	-9.8465	1.42495D-10	-9.8462	1.00061D+00	.0003
276	HF2 -	-1.0	5.26717D-16	-15.2768	5.00629D-16	-15.3005	9.46877D-01	-.0237
277	H2F2 AQ	.0	1.56521D-19	-16.8054	1.56617D-19	-16.8051	1.00061D+00	.0003
284	UO2+ 2+	2.0	8.11358D-29	-28.0908	6.52059D-29	-28.1856	8.03848D-01	-.0948
285	UO2+ 3+	1.0	4.70983D-25	-24.3274	4.45564D-25	-24.3511	9.46877D-01	-.0237
286	UO2+ 4+	.0	5.89138D-22	-21.2298	5.89496D-22	-21.2295	1.00061D+00	.0003
287	UO2(OH)2	-1.0	6.46387D-20	-19.1895	6.17845D-20	-19.2132	9.46877D-01	-.0237
301	UO2+ +1	1.0	1.42140D-08	-7.8473	1.34589D-08	-7.8710	9.46877D-01	-.0237
302	UO2(OH)2	2.0	3.64706D-11	-10.4381	2.97168D-11	-10.5328	8.03848D-01	-.0948

306	UO2CO3)3	-4.0	2.898830-09	-8.5378	1.21037D-09	-8.9171	4.17537D-01	-.3793
307	UO2F +1	1.0	1.84462D-10	-9.7341	1.74663D-10	-9.7578	9.46877D-01	-.0237
308	UO2F2 AQ	.0	1.33170D-12	-11.8756	1.33251D-12	-11.8753	1.00061D+00	.0003
309	UO2F3 -1	-1.0	4.23458D-16	-15.3732	4.00962D-16	-15.3969	9.46877D-01	-.0237
310	UO2F4 2-	-2.0	9.88975D-21	-20.0048	7.94985D-21	-20.0996	8.03848D-01	-.0948
311	UO2CL +1	1.0	1.35157D-13	-12.8692	1.27977D-13	-12.8929	9.46877D-01	-.0237
312	UO2SO4 A	.0	1.76534D-10	-9.7532	1.76642D-10	-9.7529	1.00061D+00	.0003
313	UO2SO4)2	-2.0	2.81788D-12	-11.5501	2.26515D-12	-11.6449	8.03848D-01	-.0946

STEP NUMBER 5

.05D = FRACTION OF SOLUTION 1. .95D = FRACTION OF SOLUTION 2.

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	1.622886D-07	-6.7897
C	8.137869D-04	-3.0895
CA	7.063470D-04	-3.1510
CD	1.562765D-08	-7.8061
CL	1.395769D-04	-3.8552
F	1.926393D-06	-5.7148
FE	1.887162D-07	-6.7242
K	2.547717D-05	-4.5936
MG	1.634911D-04	-3.7865
MN	5.152239D-06	-5.2881
N	4.047005D-06	-5.3918
NA	8.120775D-04	-3.0904
S	1.860739D-03	-2.9747
U	1.555671D-06	-5.8081
ZN	1.675076D-06	-5.7761
MO	1.002999D-06	-5.9971

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CALCULATIONS TERMINATED AT 200 ITERATIONS

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TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	1.622886D-07	-6.7897
C	8.137869D-04	-3.0895
CA	7.063470D-04	-3.1510
CD	1.562765D-08	-7.8061
CL	1.395769D-04	-3.8552
F	1.926393D-06	-5.7148
FE	1.887162D-07	-6.7242
K	2.547717D-05	-4.5936
MG	1.634911D-04	-3.7865
MN	5.152239D-06	-5.2881
N	4.047005D-06	-5.3918
NA	8.120775D-04	-3.0904
[illegible]	[illegible]	[illegible]

U	1.555631D-06	-5.8081
ZN	1.635278D-06	-5.7864
MO	1.022955D-06	-5.9901

----DESCRIPTION OF SOLUTION----

PH =	6.8138
PE =	6.6849
ACTIVITY H2O =	.9999
IONIC STRENGTH =	.0043
TEMPERATURE =	.5750
ELECTRICAL BALANCE =	-2.0132D-04
THOR =	9.6239D-03
TOTAL ALKALINITY =	5.3586D-04
ITERATIONS =	201

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.644330-07	-6.7840	1.535470-07	-6.8138	9.337990-01	-.0297
2	E-	-1.0	2.065910-07	-6.6849	2.065910-07	-6.6849	1.000000-00	.0000
3	H2O	.0	9.999380-01	-.0000	9.999380-01	-.0000	1.000000-00	.0000
6	H3ASO4	.0	1.405690-12	-11.8521	1.407090-12	-11.8517	1.001000-00	.0004
10	CO3 2-	-2.0	1.022990-07	-6.9903	7.775230-08	-7.1093	7.603500-01	-.1190
11	CA 2+	2.0	6.446090-04	-3.1907	4.956760-04	-3.3046	7.689660-01	-.1141
12	CO 2+	2.0	1.313840-08	-7.8815	9.999750-09	-8.0004	7.603500-01	-.1190
13	CL-	-1.0	1.395750-04	-3.8550	1.301460-04	-3.8856	9.324630-01	-.0306
16	F-	-1.0	1.915650-06	-5.7177	1.788640-06	-5.7474	9.337990-01	-.0297
17	FE 2+	2.0	1.143570-07	-6.9417	8.699170-08	-7.0607	7.603500-01	-.1190
19	K+	1.0	2.539350-05	-4.5953	2.367850-05	-4.6254	9.324630-01	-.0306
21	MG 2+	2.0	1.503740-04	-3.8225	1.139990-04	-3.9397	7.711350-01	-.1129
22	MN 2+	2.0	4.775610-06	-5.3210	3.631290-06	-5.4399	7.603500-01	-.1190
23	NO3 -	-1.0	8.101550-14	-13.0914	7.565250-14	-13.1212	9.337990-01	-.0297
24	NA+	1.0	8.094060-04	-3.0919	7.562360-04	-3.1213	9.343050-01	-.0295
29	SO4 2-	-2.0	9.639470-04	-3.0160	7.472430-04	-3.1265	7.594300-01	-.1195
32	UO2 2+	2.0	1.387180-09	-8.8579	1.054740-09	-8.9769	7.603500-01	-.1190
34	ZN 2+	2.0	1.457250-06	-5.8345	1.108020-06	-5.9555	7.603500-01	-.1190
35	MOO4 2-	-2.0	1.022960-06	-5.9901	7.778050-07	-6.1091	7.603500-01	-.1190
51	H3ASO3	.0	3.611610-18	-17.4423	3.615220-18	-17.4419	1.001000+00	.0004
53	FE 3+	3.0	1.606400-14	-13.7941	8.470310-15	-14.0619	5.398600-01	-.2677
54	MN 3+	3.0	2.093340-26	-25.6791	1.110220-26	-25.9468	5.398600-01	-.2677
55	NH4 +	1.0	4.008400-06	-5.3970	3.743040-06	-5.4268	9.337990-01	-.0297
56	NO2 -	-1.0	2.204690-11	-10.6567	2.058740-11	-10.6864	9.337990-01	-.0297
61	UO2 +	1.0	2.337950-13	-12.6312	2.183180-13	-12.6609	9.337990-01	-.0297
65	OH-	-1.0	9.390130-09	-8.0273	8.768490-09	-8.0571	9.337990-01	-.0297
75	NH4SO4 -	-1.0	3.858500-05	-7.4136	3.603060-05	-7.4433	9.337990-01	-.0297
76	MGOH +	1.0	1.334700-10	-9.8749	1.246750-10	-9.9044	9.337990-01	-.0297
77	MGF +	1.0	7.259810-09	-8.1391	6.779200-09	-8.1688	9.337990-01	-.0297
78	MGCO3 AQ	.0	5.907390-09	-8.2284	5.913290-09	-8.2283	1.001000+00	.0004
79	MGHCO3 +	1.0	6.346410-07	-6.1973	5.928140-07	-6.2271	9.337990-01	-.0297
80	MGSO4 AQ	.0	1.248900-05	-4.9034	1.248150-05	-4.9037	1.001000+00	.0004
82	CAOH +	1.0	9.773260-11	-10.0100	9.126260-11	-10.0397	9.337990-01	-.0297
83	CAHCO3 +	1.0	1.287210-06	-5.8904	1.201990-06	-5.9201	9.337990-01	-.0297
84	CACO3 AQ	.0	3.956470-05	-7.4027	3.960410-05	-7.4027	1.001000+00	.0004
87	CASO4 AQ	.0	6.040650-05	-4.2189	6.046680-05	-4.2185	1.001000+00	.0004
91	CAF +	1.0	4.667810-09	-8.3314	4.358790-09	-8.3614	9.337990-01	-.0297
92	NAF -	-1.0	3.050060-10	-9.5157	2.848160-10	-9.5454	9.337990-01	-.0297

97	KSO4 -	-1.0	8.37120D-08	-7.0772	7.81702D-08	-7.1070	9.33799D-01	-.0297
109	FEOH +	1.0	2.62723D-11	-10.5805	2.45330D-11	-10.6102	9.33799D-01	-.0297
110	FEOH3 -1	-1.0	2.68225D-20	-19.5715	2.50468D-20	-19.6012	9.33799D-01	-.0297
111	FESO4 AQ	.0	7.09666D-09	-8.1489	7.10374D-09	-8.1485	1.00100D+00	.0004
113	FEOH2 AQ	.0	1.34296D-16	-15.8719	1.34430D-16	-15.8715	1.00100D+00	.0004
117	FEOH 2+	2.0	1.00167D-10	-9.9993	7.61618D-11	-10.1183	7.60350D-01	-.1190
119	FESO4 +	1.0	3.20343D-14	-13.4944	2.99136D-14	-13.5241	9.33799D-01	-.0297
120	FECL 2+	2.0	1.92886D-17	-16.7147	1.46661D-17	-16.8337	7.60350D-01	-.1190
121	FECL2 +	1.0	2.12205D-20	-19.6732	1.98157D-20	-19.7030	9.33799D-01	-.0297
122	FECL3 AQ	.0	2.57641D-25	-24.5890	2.57898D-25	-24.5886	1.00100D+00	.0004
123	FEOH2 +	1.0	6.60738D-08	-7.1800	6.16997D-08	-7.2097	9.33799D-01	-.0297
124	FEOH3 AQ	.0	1.03040D-09	-8.9870	1.03143D-09	-8.9866	1.00100D+00	.0004
125	FEOH4 -	-1.0	3.14196D-11	-10.5028	2.93395D-11	-10.5325	9.33799D-01	-.0297
127	FEF 2+	2.0	2.14866D-14	-13.6678	1.63373D-14	-13.7868	7.60350D-01	-.1190
128	FEF2 +	1.0	9.10093D-16	-15.0409	8.49844D-16	-15.0707	9.33799D-01	-.0297
129	FEF3 AQ	.0	2.19938D-18	-17.6577	2.20157D-18	-17.6573	1.00100D+00	.0004
130	FE(SO4)2	-1.0	6.82260D-16	-15.1661	6.37094D-16	-15.1958	9.33799D-01	-.0297
131	FE2(OH)2	4.0	1.40195D-18	-17.8533	4.68585D-19	-18.3292	3.34237D-01	-.4759
132	FE3(OH)4	5.0	3.78205D-22	-21.4223	6.82437D-23	-22.1659	1.80441D-01	-.7437
136	MNCL +	1.0	2.04760D-09	-8.6888	1.91205D-09	-8.7185	9.33799D-01	-.0297
137	MNCL2 AQ	.0	6.75311D-14	-13.1705	6.75985D-14	-13.1701	1.00100D+00	.0004
138	MNCL3 -	-1.0	4.24738D-18	-17.3719	3.96620D-18	-17.4016	9.33799D-01	-.0297
139	MNOH +	1.0	7.44385D-11	-10.1282	6.95106D-11	-10.1579	9.33799D-01	-.0297
140	MN(OH)3	-1.0	1.70217D-20	-19.7690	1.58949D-20	-19.7987	9.33799D-01	-.0297
141	MNF +	1.0	4.92468D-11	-10.3076	4.59867D-11	-10.3374	9.33799D-01	-.0297
142	MNSO4 AQ	.0	3.55767D-07	-6.4488	3.56122D-07	-6.4484	1.00100D+00	.0004
144	MNHCO3 +	1.0	1.84836D-08	-7.7332	1.72590D-08	-7.7630	9.33799D-01	-.0297
162	ZNCL +	1.0	1.28600D-10	-9.8908	1.20086D-10	-9.9205	9.33799D-01	-.0297
163	ZNCL2 AQ	.0	1.44913D-14	-13.8339	1.47060D-14	-13.8335	1.00100D+00	.0004
164	ZNCL3 -	-1.0	1.96043D-18	-17.7076	1.83065D-18	-17.7374	9.33799D-01	-.0297
165	ZNCL4 2-	-2.0	1.26901D-22	-21.8965	9.64890D-23	-22.0155	7.60350D-01	-.1190
166	ZNF +	1.0	2.14419D-11	-10.6683	2.00411D-11	-10.6981	9.33799D-01	-.0297
167	ZNOH +	1.0	1.07569D-09	-8.9683	1.00448D-09	-8.9981	9.33799D-01	-.0297
168	ZN(OH)2	.0	2.56335D-11	-10.5878	2.58596D-11	-10.5874	1.00100D+00	.0004
169	ZN(OH)3	-1.0	1.59552D-16	-15.7996	1.48055D-16	-15.8296	9.33799D-01	-.0297
170	ZN(OH)4	-2.0	2.29792D-23	-22.6390	1.74722D-23	-22.7577	7.60350D-01	-.1190
171	ZNHCO3 +	.0	3.10658D-11	-10.5077	3.10966D-11	-10.5073	1.00100D+00	.0004
174	ZNSO4 AQ	.0	1.57985D-07	-6.8014	1.58147D-07	-6.8009	1.00100D+00	.0004
175	ZN(SO4)2	-2.0	1.55045D-09	-8.8095	1.17688D-09	-8.9289	7.60350D-01	-.1190
180	ZNCO3 +	1.0	1.78340D-18	-17.7488	1.66533D-18	-17.7785	9.33799D-01	-.0297
181	ZNCO3 AQ	.0	1.71722D-08	-7.7652	1.71894D-08	-7.7647	1.00100D+00	.0004
182	ZN(CO3)2	-2.0	3.75802D-11	-10.4250	2.85741D-11	-10.5442	7.60350D-01	-.1190
183	CDCL +	1.0	1.21661D-10	-9.9146	1.13607D-10	-9.9446	9.33799D-01	-.0297
184	CDCL2 AQ	.0	5.58338D-14	-13.2531	5.58895D-14	-13.2527	1.00100D+00	.0004
185	CDCL3 -	-1.0	3.28505D-18	-17.4835	3.06758D-18	-17.5132	9.33799D-01	-.0297
186	CDF +	1.0	2.40919D-13	-12.6181	2.24970D-13	-12.6479	9.33799D-01	-.0297
187	CDF2 AQ	.0	1.00986D-18	-17.9957	1.01087D-18	-17.9953	1.00100D+00	.0004
188	CD(CO3)3	-4.0	2.33152D-23	-22.6324	7.79281D-24	-23.1063	3.34237D-01	-.4759
189	CDOH +	1.0	8.05842D-13	-12.0937	7.52495D-13	-12.1235	9.33799D-01	-.0297
190	CD(OH)2	.0	1.89053D-15	-14.7234	1.89242D-15	-14.7230	1.00100D+00	.0004
191	CD(OH)3	-1.0	1.48063D-21	-20.8295	1.38277D-21	-20.8592	9.33799D-01	-.0297
192	CD(OH)4	-2.0	1.05553D-28	-27.9765	8.02570D-29	-28.0955	7.60350D-01	-.1190
193	CD2OH +3	3.0	9.50013D-20	-19.0223	5.12874D-20	-19.2900	5.39660D-01	-.2677
194	CDHCO3 AQ	.0	1.73165D-13	-12.7615	1.73336D-13	-12.7611	1.00100D+00	.0004
195	CDCO3 +	1.0	4.43835D-23	-22.3536	4.14453D-23	-22.3829	9.33799D-01	-.0297
196	CDCO3 AQ	.0	1.97868D-09	-8.7391	1.82971D-09	-8.7376	1.00100D+00	.0004
197	CD(CO3)2 +	1.0	3.20616D-12	-9.4937	2.99577D-12	-9.5235	9.33799D-01	-.0297
198	CD(CO3)2 AQ	.0	1.94460D-12	-9.7110	1.94658D-12	-9.7107	1.00100D+00	.0004
199	CD(CO3)2	-2.0	2.31586D-11	-10.6353	1.76390D-11	-10.7539	7.60350D-01	-.1190
200	HCdO3 -	-1.0	5.55364D-21	-20.2554	5.19617D-21	-20.2852	9.33799D-01	-.0297
201	HCdO3 2-	-2.0	1.11167D-26	-25.9542	8.45755D-27	-26.0733	7.60350D-01	-.1190
202	HCdO3 +	1.0	2.94509D-25	-24.5309	2.75207D-25	-24.5607	9.33799D-01	-.0297
203	HCdO2 -	-1.0	7.03341D-23	-22.1528	6.57317D-23	-22.1826	9.33799D-01	-.0297

272	HCO3 -	-1.0	5.29389D-04	-3.2762	4.94343D-04	-3.3060	9.33799D-01	-.0297
273	H2CO3 AQ	.0	2.80124D-04	-3.5526	2.80404D-04	-3.5522	1.00100D+00	.0004
274	HSO4 -	-1.0	6.24155D-09	-8.2047	5.82835D-09	-8.2345	9.33799D-01	-.0297
275	HF AQ	.0	2.40482D-10	-9.6189	2.40722D-10	-9.6185	1.00100D+00	.0004
276	HF2 -	-1.0	1.48780D-15	-14.8275	1.38930D-15	-14.8572	9.33799D-01	-.0297
277	H2F2 AQ	.0	4.41764D-19	-18.3548	4.42205D-19	-18.3544	1.00100D+00	.0004
284	U(OH)2 +	2.0	1.52431D-28	-27.8169	1.15901D-28	-27.9359	7.60350D-01	-.1190
285	U(OH)3 +	1.0	8.33887D-25	-24.0789	7.78683D-25	-24.1086	9.33799D-01	-.0297
286	U(OH)4 A	.0	1.00770D-21	-20.9967	1.00871D-21	-20.9962	1.00100D+00	.0004
287	U(OH)5 -	-1.0	1.09934D-19	-18.9589	1.02656D-19	-18.9886	9.33799D-01	-.0297
301	UO2OH +1	1.0	1.28370D-08	-7.8915	1.19872D-08	-7.9213	9.33799D-01	-.0297
302	UO2)2OH2	2.0	3.01071D-11	-10.5213	2.28919D-11	-10.6403	7.60350D-01	-.1190
303	UO2)3OH5	1.0	8.60712D-11	-10.0651	8.03732D-11	-10.0949	9.33799D-01	-.0297
304	UO2CO3 A	.0	1.03571D-06	-5.9848	1.03674D-06	-5.9843	1.00100D+00	.0004
305	UO2(CO3)2	-2.0	4.91379D-07	-6.3086	3.73620D-07	-6.4276	7.60350D-01	-.1190
306	UO2(CO3)3	-4.0	1.34733D-08	-7.8705	4.50328D-09	-8.3465	3.34237D-01	-.4759
307	UO2F +1	1.0	2.75357D-10	-9.5601	2.57128D-10	-9.5899	9.33799D-01	-.0297
308	UO2F2 AQ	.0	3.21157D-12	-11.4933	3.21477D-12	-11.4928	1.00100D+00	.0004
309	UO2F3 -1	-1.0	1.69902D-15	-14.7698	1.58654D-15	-14.7995	9.33799D-01	-.0297
310	UO2F4 2-	-2.0	6.78201D-20	-19.1686	5.15670D-20	-19.2876	7.60350D-01	-.1190
311	UO2CL +1	1.0	2.02623D-13	-12.6933	1.89209D-13	-12.7231	9.33799D-01	-.0297
312	UO2SO4 A	.0	2.44857D-10	-9.6111	2.45102D-10	-9.6107	1.00100D+00	.0004
313	UO2SO4)2	-2.0	6.37319D-12	-11.1956	4.84585D-12	-11.3146	7.60350D-01	-.1190

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINITE	-22.3466	-14.9534	-7.3933
UO2 (AM	-22.3466	-8.81[illegible]	-13.5303
U4O9 (C)	-62.38[illegible]	-42.63[illegible]	-19.7527
U3O8 (C)	-13.0454	-5.7074	-7.3379
UF4 (C)	-70.5913	-28.6357	-42.7556
UF4 2.5H-	-72.5914	-39.0070	-33.5882
UO3 (C)	4.65[illegible]	8.9[illegible]	-4.3330
G[illegible]ITE	4.65[illegible]	11.90[illegible]	-7.2543
B[illegible]	4.6[illegible]	6.4350	-1.7674
S[illegible]ITE	4.6[illegible]	6.1691	-1.5375
R[illegible]ITE	-16.[illegible]	-14.46[illegible]	-1.6216
AN[illegible]ITE	-6.4313	-4.3934	-2.0379
A[illegible]	-10.4141	-8.1439	-2.2702
A[illegible]ITE	-1.3333	11.4797	-12.8330
BRUCITE	9.6918	18.4850	-8.7953
CALCITE	-10.4141	-8.3933	-2.0208
DOLOMITE	-21.4591	-16.4578	-5.0013
EPSOMITE	-7.0674	-2.3744	-4.7360
→ FERRIHYD	20.0654	18.5740	**1.4913** ←
FE3(OH)8	46.6975	47.5981	-.9006
→ FEOH/2.7	16.8556	10.6440	**6.2115** ←
FES PPT	-118.1763	-41.5134	-76.6630
FE2(SO4)	-10.1313	34.8147	-44.9460
FLUORITE	-14.7997	-11.2680	-3.5316
→ GOETHITE	20.0654	15.1311	**4.9343** ←
GREENITE	-452.2745	-168.0[illegible]	-264.2[illegible]
G[illegible]	-6.4[illegible]	-4.8[illegible]	-1.5[illegible]
H[illegible]ITE	-7.00[illegible]	1.5[illegible]	-8.50[illegible]
→ HEMATITE	40.1375	25.3[illegible]	**14.7450** ←
HUNTITE	-43.5[illegible]	-28.2[illegible]	-15.2[illegible]
HYDROMAG[illegible]	-3[illegible].4[illegible]	-5.3[illegible]	-29.1[illegible]
JA[illegible]ITE	26.6[illegible]	32.5[illegible]	-5.8[illegible]
MAGNA[illegible]	-115.1743	-40.2434	-75.9[illegible]
→ MAGHEMITE	40.1375	33.7[illegible]	**6.3727** ←
MAGNESITE	-11.0480	-[illegible]	-[illegible]
→			←

MAXHABIT	-1.3615	-2.3522	-7.[illegible]75
NATRON	-13.3522	-2.3394	-11.0128
NESQUEHO	-11.0451	-5.2413	-5.8037
PYRITE	-215.9222	-94.4058	-121.5164
SIDERITE	-14.1700	-10.2014	-3.9686
THENARDI	-9.3692	-.1427	-9.2265
THERMONA	-13.3520	.3131	-13.6651
PYROLUSI	35.1848	44.9633	-9.7784
BIRNESSI	35.1848	45.2848	-10.1000
NSUTITE	35.1848	44.6948	-9.5100
BIXBYITE	43.3724	54.7663	-11.3940
HAUSMANN	51.5599	66.7814	-15.2215
PYROCROI	8.1875	16.5675	-8.3799
MANGANIT	21.6862	26.9548	-5.2686
RHODOCHR	-12.5492	-10.2740	-2.2753
MNCL2, 4	-13.2112	1.5733	-14.7845
MNS GREE	-116.5556	-33.4147	-83.1409
MNSO4	-8.5665	3.6824	-12.2489
MN2(SO4)	-6.8897	51.2242	-58.1139
ZN METAL	-19.3252	28.1655	-47.4908
ZNCL2	-13.7266	8.1732	-21.8998
SMITHSON	-13.0647	-9.7148	-3.3499
ZNCO3, 1	-13.0648	-10.2600	-2.8048
ZNF2	-17.4503	-.6645	-16.7858
ZN(OH)2	7.6720	11.5000	-3.8280
ZN2(OH)3	4.6447	15.2000	-10.5553
ZN5(OH)8	16.9615	38.5000	-21.5385
ZN2(OH)2	-1.4100	7.5000	-8.9100
ZN4(OH)6	13.9340	28.4000	-14.4660
ZNNO3,2	-36.1960	3.0796	-39.2776
ZNO(ACT)	7.6720	11.3100	-3.6380
ZINCITE	7.6720	12.5697	-4.8977
ZNSO(SO4	-10.4919	23.0750	-33.5670
ZNS (A	-117.0711	-46.8834	-70.1877
SPHALERI	-117.0711	-49.7539	-67.3151
WURTZITE	-117.0711	-47.6247	-69.4465
ZINCITE	-9.0800	4.3457	-13.3477
ZNSO4, 1	-9.0800	.1259	-9.2079
ZNSO4(H2	-9.0800	-1.7495	-7.3306
GOSLARITE	-9.0800	-2.1756	-6.9053
CD METAL	-21.3700	14.6677	-36.0375
GAMMA CD	-21.3700	14.7764	-36.1464
OTAVITE	-15.1097	-13.7021	-1.4077
CDCL2	-15.7716	-.3876	-15.3839
CDCL2, 1	-15.7716	-1.5910	-14.1806
CDCL2,2	-15.7716	-2.0518	-13.7198
CDF2	-19.4953	-2.3443	-17.1510
CD(OH)2	5.6270	13.6500	-8.0230
CDOHCL	-5.0723	4.0046	-9.0769
CD3(OH)4	.1271	22.5600	-22.4329
CD3OH2(S	-16.6269	6.7100	-23.3369
CD4(OH)6	5.7541	28.4000	-22.6459
MONTEPON	5.6270	16.7394	-11.1123
CDSO4	-11.1270	.8640	-11.9910
CDSO4, 1	-11.1270	-1.1650	-9.9620
CDSO4,2	-11.1270	-1.5888	-9.5382
GREENOCK	-115.1161	-54.5677	-60.5484
ARSENIC	-155.3956	-89.3495	-66.0461
CL4 [illegible]	-155.3956	-89.5619	-65.8341
ORPIMENT	-481.9771	-221.9875	-259.9896
REALGAR	-177.0916	-80.7440	-96.3476
ARSTE	-23.7777	7.0878	-30.7571
S[illegible]	-97.7458	-39.4787	-58.3170
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
MN3AS042	.8592	12.5000	-11.6408
ZN3AS042	-.6872	13.6500	-14.3372
LIME	10.3227	35.8256	-25.5029
PORTLAND	10.3227	24.6772	-14.3546
WUSTITE	7.6496	13.3153	-5.6657
PERICLAS	9.6918	23.8730	-14.1812
MAG-FERR	49.8226	48.4965	1.3261
LEPIDOCR	20.0654	15.0540	5.0114
FE(OH)3S	20.0654	16.3540	3.7113
NA2SO3	-36.3665	5.1436	-41.5101
K2SO3	-39.3751	8.3526	-47.7277
CASO3.2H	-33.4267	-3.6795	-29.7492
CASO3.5H	-33.4286	-3.1138	-30.3148
MGSO3	-34.0595	7.7041	-41.7636
CH4(GAS)	-128.7259	-45.0696	-83.6563
CO2(GAS)	-20.7368	-18.1947	-2.5421
O2(GAS)	53.9945	92.0561	-38.0615
CAMOO4	-9.4139	-7.7658	-1.6481

L.M. COONS PE, PHG

OCT '90

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ELEMENTS
SPECIES
LOOK MIN
   :IATION OF TAILINGS PORE FLUID/MW-605 MIX UNDER MW-607 ENVIRONMENT
..0010000 0 0          .00000
SOLUTION 1
2.5% TAILINGS PORE FLUID WITH CLIFF HOUSE BKGRND (MW-605)
16  0 0     6.83     -.496      10.5      1.00
   6  8.1100-06  10  4.0700-04  11  3.5300-04  12  7.8100-09  13  6.9800-05
  16  9.6400-07  17  9.4300-06  19  1.2700-05  21  8.1700-05  22  2.5800-06
  23  2.0200-06  24  4.0600-04  29  5.3000-04  32  7.7800-07  34  8.1700-07
  35  5.1100-07
MINERALS
          0     .000      .000      .000        0              .000
NUMBER OF MINERALS FOUND   0
NUMBER OF MINERALS USED   0
**          ** INPUT UNKNOWN
SOLUTION NUMBER 1          2.5% TAILINGS PORE FLUID WITH CLIFF HOUSE BKGRND (MW-605)
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10/1/90 (All B 2 pages were checked g.)

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	8.1100000-08	-7.0910
C	4.0700000-04	-3.3904
CA	3.5300000-04	-3.4522
CD	7.8100000-09	-8.1073
CL	6.9800000-05	-4.1561
F	9.6400000-07	-6.0159
FE	9.4300000-06	-7.0255
K	1.2700000-05	-4.8962
MG	8.1700000-05	-4.0878
MN	2.5800000-06	-5.5884
N	2.0200000-06	-5.6946
NA	4.0600000-04	-3.3919
S	5.3000000-04	-3.2757
SE	7.7800000-07	-6.1090
ZN	8.1700000-07	-6.0878
MO	5.1100000-07	-6.2918

2.5 % OF TAILINGS PORE FLUID
+
97.5% MW-605 groundwater

----DESCRIPTION OF SOLUTION----

PH =	6.8300
PE =	-.4957
ACTIVITY H2O =	1.0000
IONIC STRENGTH =	.0002
TEMPERATURE =	10.5000
ELECTRICAL BALANCE =	-1.2549D-04
%-DIF =	-3.1263D-01
TOTAL ALKALINITY =	2.9354D-04
ITERATIONS =	19

MW-607 ENVIRON

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.55656D-07	-6.8078	1.47911D-07	-6.8300	9.50239D-01	-.0222
2	E-	-1.0	3.13112D+00	.4957	3.13112D+00	.4957	1.00000D+00	.0000
3	H2O	.0	9.99969D-01	-.0000	9.99969D-01	-.0000	1.00000D+00	.0000
6	H3AS04	.0	1.01711D-15	-14.9926	1.01763D-15	-14.9924	1.00051D+00	.0002
10	CO3 2-	-2.0	7.51358D-08	-7.1242	6.12602D-08	-7.2128	8.15326D-01	-.0887
11	CA 2+	2.0	3.32336D-04	-3.4764	2.72690D-04	-3.5643	8.20525D-01	-.0859
12	CD 2+	2.0	6.93610D-09	-8.1589	5.65519D-09	-8.2476	8.15326D-01	-.0887
13	CL-	-1.0	6.97993D-05	-4.1561	6.62770D-05	-4.1786	9.49536D-01	-.0225
16	F-	-1.0	9.59435D-07	-6.0180	9.11692D-07	-6.0402	9.50239D-01	-.0222
17	FE 2+	2.0	9.01786D-08	-7.0449	7.35250D-08	-7.1336	8.15326D-01	-.0887
19	K+	1.0	1.26719D-05	-4.8972	1.20325D-05	-4.9196	9.49536D-01	-.0225
21	MG 2+	2.0	7.73754D-05	-4.1114	6.35882D-05	-4.1966	8.21815D-01	-.0852
22	MN 2+	2.0	2.44791D-06	-5.6112	1.99585D-06	-5.6999	8.15326D-01	-.0887
23	NO3 -	-1.0	0.00000D+00	-67.4482	0.00000D+00	-67.4704	9.50239D-01	-.0222
24	NA+	1.0	4.05199D-04	-3.3923	3.85159D-04	-3.4144	9.50544D-01	-.0220
29	SO4 2-	-2.0	5.04777D-04	-3.2969	4.11366D-04	-3.3858	8.14950D-01	-.0889
32	UO2 2+	2.0	4.86565D-11	-10.3129	3.96710D-11	-10.4015	8.15326D-01	-.0887
34	ZN 2+	2.0	7.54893D-07	-6.1221	6.15484D-07	-6.2108	8.15326D-01	-.0887
35	MOO4 2-	-2.0	5.11000D-07	-6.2916	4.16632D-07	-6.3802	8.15326D-01	-.0887
51	H3AS03	.0	8.07973D-08	-7.0926	8.08388D-08	-7.0924	1.00051D+00	.0002
53	FE 3+	3.0	1.45732D-21	-20.8364	9.20556D-22	-21.0359	6.31678D-01	-.1995
55	NH4 +	1.0	2.00935D-06	-5.6969	1.90936D-06	-5.7191	9.50239D-01	-.0222
57	HS-	-1.0	1.11020D-25	-24.9546	1.05496D-25	-24.9768	9.50239D-01	-.0222
58	SO3 2-	-2.0	3.11151D-20	-19.5070	2.53690D-20	-19.5957	8.15326D-01	-.0887
60	U 4+	4.0	1.35086D-26	-25.8694	5.96949D-27	-26.2241	4.41902D-01	-.3547
61	UO2 +	1.0	1.05922D-07	-6.9750	1.00651D-07	-6.9972	9.50239D-01	-.0222
65	OH-	-1.0	2.26015D-08	-7.6459	2.14768D-08	-7.6681	9.50239D-01	-.0222
75	NH4SO4 -	-1.0	1.06483D-08	-7.9727	1.01184D-08	-7.9949	9.50239D-01	-.0222
76	MSO+ +	1.0	1.98114D-10	-9.7031	1.88256D-10	-9.7253	9.50239D-01	-.0222
77	MGF +	1.0	2.69318D-09	-8.5697	2.55916D-09	-8.5919	9.50239D-01	-.0222
78	MGCO3 AQ	.0	2.97403D-09	-8.5267	2.97555D-09	-8.5264	1.00051D+00	.0002
79	MG-CO3 +	1.0	1.98115D-07	-6.7031	1.88356D-07	-6.7253	9.50239D-01	-.0222
80	MGSO4 AQ	.0	4.12865D-06	-5.3850	4.12277D-06	-5.3846	1.00051D+00	.0002
84	CAO+ +	1.0	1.39708D-10	-9.8548	1.32756D-10	-9.8769	9.50239D-01	-.0222
85	CA-CO3 +	1.0	5.24684D-07	-6.2801	4.98575D-07	-6.3023	9.50239D-01	-.0222
86	CACO3 AQ	.0	1.64939D-08	-7.7339	1.64633D-08	-7.7337	1.00051D+00	.0002
87	CASO4 AQ	.0	2.01187D-05	-4.6964	2.01290D-05	-4.6962	1.00051D+00	.0002
91	CAF +	1.0	1.64703D-09	-8.7844	1.56032D-09	-8.8066	9.50239D-01	-.0222
92	NACO3 -	-1.0	2.13356D-10	-9.6729	2.02739D-10	-9.6951	9.50239D-01	-.0222
93	NA-CO3 +	1.0	4.19369D-08	-7.3774	4.19584D-08	-7.3772	1.00051D+00	.0002
94	NASO4 -	-1.0	7.58706D-07	-6.1199	7.23952D-07	-6.1421	9.50239D-01	-.0222
96	NAF AQ	.0	5.69201D-11	-10.2447	5.69494D-11	-10.2445	1.00051D+00	.0002
97	KSO4 -	-1.0	2.80594D-08	-7.5519	2.66631D-08	-7.5741	9.50239D-01	-.0222
109	FEO+ +	1.0	5.29716D-11	-10.2760	5.03356D-11	-10.2981	9.50239D-01	-.0222
110	FEO+3 -1	-1.0	1.75093D-19	-18.7567	1.66380D-19	-18.7789	9.50239D-01	-.0222
111	FESO4 AQ	.0	4.06837D-09	-8.3906	4.07045D-09	-8.3904	1.00051D+00	.0002
113	FEO+2 AQ	.0	7.68953D-16	-15.1141	7.69347D-16	-15.1139	1.00051D+00	.0002
117	FEO+ 2+	2.0	2.00942D-17	-16.6969	1.63634D-17	-16.7856	8.15326D-01	-.0887
119	FESO4 +	1.0	2.36563D-21	-20.6261	2.24791D-21	-20.6482	9.50239D-01	-.0222
120	FECL 2+	2.0	1.39399D-24	-23.8557	1.13656D-24	-23.9444	8.15326D-01	-.0887
121	FECL2 +	1.0	5.74041D-28	-27.2411	5.45477D-28	-27.2632	9.50239D-01	-.0222
123	FEOH2 +	1.0	2.20280D-14	-13.6570	2.09319D-14	-13.6792	9.50239D-01	-.0222
124	FEO+3 AQ	.0	6.95249D-16	-15.1579	6.95605D-16	-15.1576	1.00051D+00	.0002
125	FEO+4 -	-1.0	3.07922D-17	-16.5116	2.92600D-17	-16.5337	9.50239D-01	-.0222
127	FEF 2+	2.0	1.28956D-21	-20.8896	1.05141D-21	-20.9780	8.15326D-01	-.0887
128	FEF2 +	1.0	3.35789D-23	-22.4739	3.19263D-23	-22.4961	9.50239D-01	-.0222
129	FEF3 AQ	.0	4.37604D-26	-25.3589	4.37628D-26	-25.3587	1.00051D+00	.0002
130	FESO4F +	-1.0	2.89951D-23	-22.5377	2.75523D-23	-22.5598	9.50239D-01	-.0222
136	MNCL +	1.0	5.63193D-10	-9.2493	5.35168D-10	-9.2715	9.50239D-01	-.0222
137	MNCL2 AQ	.0	9.63006D-15	-14.0164	9.63502D-15	-14.0161	1.00051D+00	.0002
138	MNCL3 -	-1.0	3.02958D-19	-18.5186	2.87853D-19	-18.5408	9.50239D-01	-.0222
139	MNF +	1.0	1.05887D-10	-9.9770	1.00140D-10	-9.9992	9.50239D-01	-.0222

141	MNF +	1.0	1.33363D-11	-10.8679	1.28818D-11	-10.8900	9.50239D-01	-.0222
142	MNSO4 AQ	.0	1.23831D-07	-6.9072	1.23894D-07	-6.9069	1.00051D+00	.0002
144	MNHCO3 +	1.0	7.57658D-09	-8.1205	7.19956D-09	-8.1427	9.50239D-01	-.0222
162	ZNCL +	1.0	5.90021D-11	-10.2291	5.60661D-11	-10.2513	9.50239D-01	-.0222
163	ZNCL2 AQ	.0	3.65795D-15	-14.4368	3.65983D-15	-14.4365	1.00051D+00	.0002
164	ZNCL3 -	-1.0	2.61381D-19	-18.5827	2.48374D-19	-18.6049	9.50239D-01	-.0222
165	ZNCL4 2-	-2.0	8.94710D-24	-23.0483	7.29481D-24	-23.1370	8.15326D-01	-.0887
166	ZNF +	1.0	6.88735D-12	-11.1619	6.54463D-12	-11.1841	9.50239D-01	-.0222
167	ZNOH +	1.0	1.44322D-09	-8.8407	1.37140D-09	-8.8628	9.50239D-01	-.0222
168	ZN(OH)2	.0	5.89690D-11	-10.2294	5.89993D-11	-10.2292	1.00051D+00	.0002
169	ZN(OH)3	-1.0	6.37557D-16	-15.1955	6.05831D-16	-15.2176	9.50239D-01	-.0222
170	ZN(OH)4	-2.0	2.29857D-22	-21.6385	1.87409D-22	-21.7272	8.15326D-01	-.0887
171	ZNOHCL A	.0	9.12732D-12	-11.0397	9.13200D-12	-11.0394	1.00051D+00	.0002
174	ZNSO4 AQ	.0	5.27555D-08	-7.2777	5.27825D-08	-7.2775	1.00051D+00	.0002
175	ZN(SO4)2	-2.0	2.43414D-10	-9.6137	1.98462D-10	-9.7023	8.15326D-01	-.0887
180	ZNHCO3 +	1.0	7.38860D-19	-18.1314	7.02094D-19	-18.1536	9.50239D-01	-.0222
181	ZNCO3 AQ	.0	7.51922D-09	-8.1238	7.52308D-09	-8.1236	1.00051D+00	.0002
182	ZN(CO3)2	-2.0	1.20849D-11	-10.9178	9.85313D-12	-11.0064	8.15326D-01	-.0887
183	CDCL +	1.0	3.57990D-11	-10.4461	3.40176D-11	-10.4683	9.50239D-01	-.0222
184	CDCL2 AQ	.0	8.88155D-15	-14.0515	8.88611D-15	-14.0513	1.00051D+00	.0002
185	CDCL3 -	-1.0	3.10153D-19	-18.5084	2.94719D-19	-18.5306	9.50239D-01	-.0222
186	CDF +	1.0	6.83066D-14	-13.1655	6.49076D-14	-13.1877	9.50239D-01	-.0222
187	CDF2 AQ	.0	1.48567D-19	-18.8281	1.48643D-19	-18.8279	1.00051D+00	.0002
188	CD(CO3)3	-4.0	4.88267D-24	-23.3113	2.15766D-24	-23.6660	4.41902D-01	-.3547
189	CDOH +	1.0	1.08085D-12	-11.9662	1.02706D-12	-11.9884	9.50239D-01	-.0222
190	CD(OH)2	.0	1.15396D-15	-14.9376	1.15457D-15	-14.9376	1.00051D+00	.0002
191	CD(OH)3	-1.0	9.21647D-22	-21.0354	8.75804D-22	-21.0576	9.50239D-01	-.0222
192	CD(OH)4	-2.0	6.47236D-29	-28.1889	5.27709D-29	-28.2776	8.15326D-01	-.0887
193	CD2OH +3	3.0	5.44523D-20	-19.2640	3.43963D-20	-19.4635	6.31678D-01	-.1995
194	CDOHCL A	.0	6.86118D-14	-13.1636	6.86470D-14	-13.1634	1.00051D+00	.0002
196	CDSO4 AQ	.0	6.10927D-10	-9.2140	6.11240D-10	-9.2138	1.00051D+00	.0002
197	CDHS +	1.0	9.26646D-24	-23.0321	8.82436D-24	-23.0543	9.50239D-01	-.0222
205	CDHCO3 +	1.0	1.35454D-10	-9.8662	1.28714D-10	-9.8904	9.50239D-01	-.0222
206	CDCO3 AQ	.0	8.67767D-11	-10.0616	8.68212D-11	-10.0614	1.00051D+00	.0002
207	CD(SO4)2	-2.0	3.71173D-12	-11.4304	3.02627D-12	-11.5191	8.15326D-01	-.0887
265	H2SO3 -	-1.0	1.93194D-10	-9.7140	1.83561D-10	-9.7362	9.50239D-01	-.0222
266	H4SO3 2-	-2.0	6.22693D-16	-15.2057	5.07698D-16	-15.2944	8.15326D-01	-.0887
267	ASO3 -3	-3.0	1.24276D-22	-21.9056	7.85025D-23	-22.1051	6.31678D-01	-.1995
268	H4ASO3 +	1.0	6.23428D-15	-14.2052	5.92406D-15	-14.2274	9.50239D-01	-.0222
269	H2ASO4 -	-1.0	4.78718D-11	-10.3199	4.54897D-11	-10.3421	9.50239D-01	-.0222
270	H4SO4 2-	-2.0	6.16211D-11	-10.2103	5.02413D-11	-10.2989	8.15326D-01	-.0887
271	ASO4 -3	-3.0	9.36651D-16	-15.0284	5.91662D-16	-15.2279	6.31678D-01	-.1995
272	HCO3 -	-1.0	2.69434D-04	-3.5385	2.75031D-04	-3.5606	9.50239D-01	-.0222
273	H2CO3 AQ	.0	1.16633D-04	-3.9332	1.16693D-04	-3.9330	1.00051D+00	.0002
274	HSO4 -	-1.0	4.19806D-09	-8.3770	3.98916D-09	-8.399[illegible]	9.50239D-01	-.0222
275	HF AQ	.0	1.47565D-10	-9.8310	1.47641D-10	-9.8308	1.00051D+00	.0002
276	HF2 -	-1.0	4.90210D-16	-15.3096	4.65817D-16	-15.3318	9.50239D-01	-.0222
277	H2F2 AQ	.0	1.06530D-19	-18.9725	1.06585D-19	-18.9723	1.00051D+00	.0002
281	H2S AQ	.0	2.42994D-25	-24.6144	2.43119D-25	-24.6142	1.00051D+00	.0002
283	UOH +3	3.0	5.13436D-21	-20.2895	3.24326D-21	-20.4890	6.31678D-01	-.1995
284	U(OH)2 +	2.0	3.89282D-16	-15.4097	3.17392D-16	-15.4984	8.15326D-01	-.0887
285	U(OH)3 +	1.0	3.19589D-12	-11.4954	3.03686D-12	-11.5176	9.50239D-01	-.0222
286	U(OH)4 A	.0	4.67673D-09	-8.3301	4.67913D-09	-8.3298	1.00051D+00	.0002
287	U(OH)5 -	-1.0	6.23512D-07	-6.2052	5.92486D-07	-6.2273	9.50239D-01	-.0222
288	UF +3	3.0	2.54141D-24	-23.5949	1.60535D-24	-23.7944	6.31678D-01	-.1995
289	UF2 2+	2.0	9.36550D-25	-24.0285	7.63594D-25	-24.1171	8.15326D-01	-.0887
290	UF3 +1	1.0	3.34773D-26	-25.4753	3.18114D-26	-25.4974	9.50239D-01	-.0222
291	UF4 AQ	.0	1.20991D-27	-26.9172	1.21053D-27	-26.9170	1.00051D+00	.0002
292	UO2 +3	3.0	5.78936D-30	-29.2374	3.65771D-30	-29.4369	6.31678D-01	-.1995
293	UO2(OH)2 2+	2.0	4.33728D-25	-24.1986	3.53864D-25	-24.2875	8.15326D-01	-.0887
294	UO2(OH)4	.0	2.94047D-24	-23.5316	2.94197D-24	-23.5314	1.00051D+00	.0002
301	UO2CO3 +1	1.0	9.50274D-10	-9.0222	9.02987D-10	-9.0443	9.50239D-01	-.0222
302	UO2(CO3)2	2.0	8.26580D-14	-13.0827	6.73933D-14	-13.1714	8.15326D-01	-.0887
303	UO2(CO3)3	1.0	2.72268D-14	-13.5657	2.58722D-14	-13.5872	9.50239D-01	-.0222
304	UO2CO3 A	.0	2.94451D-08	-7.5310	2.94503D-08	-7.5308	1.00051D+00	.0002

306	UO2CO3)3	-4.0	1.06575D-10	-9.9723	[illegible]	[illegible]	[illegible]	[illegible]
307	UO2F +1	1.0	5.03905D-12	-11.2977	4.78831D-12	-11.3198	9.50239D-01	-.0222
308	UO2F2 AQ	.0	2.96257D-14	-13.5283	2.96409D-14	-13.5281	1.00051D+00	.0002
309	UO2F3 -1	-1.0	7.87106D-18	-17.1040	7.47938D-18	-17.1261	9.50239D-01	-.0222
310	UO2F4 2-	-2.0	1.49537D-22	-21.8253	1.21922D-22	-21.9139	8.15326D-01	-.0887
311	UO2CL +1	1.0	4.12861D-15	-14.3842	3.92317D-15	-14.4064	9.50239D-01	-.0222
312	UO2SO4 A	.0	5.99468D-12	-11.2222	5.99776D-12	-11.2220	1.00051D+00	.0002
313	UO2SO4)2	-2.0	8.44957D-14	-13.0732	6.88916D-14	-13.1618	8.15326D-01	-.0887
353	HSO3-	-1.0	5.86827D-20	-19.2315	5.57626D-20	-19.2537	9.50239D-01	-.0222
354	H2SO3 AQ	.0	2.99173D-25	-24.5241	2.99327D-25	-24.5239	1.00051D+00	.0002

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-9.4101	-14.5120	5.1019
UO2 (AM	-9.4101	-8.5872	-.8229
U409 (C)	-24.9719	-41.6172	16.6453
U3O8 (C)	-2.8932	-6.0630	3.1698
UF4 (C)	-60.8907	-28.4019	-32.4888
UF4.2.5H	-60.8907	-38.0579	-22.8328
UO3 (C)	3.2585	8.4439	-5.1854
GUMMITE	3.2585	11.2621	-8.0037
B-UO2(O-	3.2584	6.0544	-2.7960
SCHOEPIT	3.2584	5.8515	-2.5931
RUTHERFO	-17.6143	-14.4467	-3.1677
ANHYDRIT	-6.9501	-4.4987	-2.4514
ARAGONIT	-10.7772	-8.2145	-2.5626
ARTINITE	-1.9461	10.6768	-12.6230
BRUCITE	9.4633	17.7582	-8.2948
CALCITE	-10.7772	-8.4078	-2.3693
DOLOMITE	-22.1866	-16.689-	-5.4972
EPSOMITE	-7.5825	-2.2457	-5.3368
FERRIHYD	12.8607	18.2947	-5.4340
FE3(OH)8	32.2478	47.0394	-14.7916
FE(OH)2.7	9.5581	10.3647	-.8066
FES PPT	-61.1937	-39.8334	-21.3603
FE2(SO4)	-25.4158	32.6045	-58.0203
FLUORITE	-15.6448	-11.1365	-4.5082
GOETHITE	12.8607	14.4472	-1.5865
GREIGITE	-238.6326	-161.8740	-76.7585
GYPSUM	-6.9501	-4.8597	-2.0904
HALITE	-7.5930	1.5455	-9.1385
HEMATITE	25.7214	23.9653	1.7562
HUNTITE	-45.0055	-29.0048	-16.0007
HYDRMAGN	-36.1745	-6.8138	-29.3607
JAROSITE	4.4906	30.1904	-25.6999
MACKINAW	-61.1937	-40.5634	-20.6303
MAGHEMIT	25.7214	33.1994	-7.4779
MAGNESIT	-11.4094	-7.7988	-3.6106
MAGNETIT	32.2479	32.4400	-.1922
MELANTER	-10.5194	-2.5772	-7.9423
MIRABILI	-10.2146	-1.8215	-8.3931
NATRON	-14.0417	-1.8998	-12.1419
NESQUEHO	-11.4095	-5.4031	-6.0064
PYRITE	-116.2452	-90.7301	-25.5151
SIDERITE	-14.3464	-10.3503	-3.9961
THENARDI	-10.2145	-.1586	-10.0559
THERMONA	-14.0416	.2349	-14.2765
PYROLUSI	20.6287	43.4285	-22.7998
BIRNESSI	20.6287	44.5652	-23.9365
NSUTITE	20.6287	43.9752	-23.3465
BIXBYITE	28.5888	53.9014	-24.3126
HAUSMANN	36.5489	64.5407	-27.9918
[illegible]	[illegible]	[illegible]	[illegible]

RHODOCHR	-12.1127	-10.5921	-2.5206
MNCL2, 4	-14.0572	2.0588	-16.1160
MNS GREE	-59.7600	-31.8964	-27.8636
MNSO4	-9.0856	3.2500	-12.3357
MN2(SO4)	-22.5485	48.6939	-71.2423
ZN METAL	-5.2194	27.1381	-32.3575
ZNCL2	-14.5681	7.6849	-22.2530
SMITHSON	-13.4236	-9.8366	-3.5870
ZNCO3, 1	-13.4236	-10.2600	-3.1636
ZNF2	-18.2911	-1.0299	-17.2612
ZN(OH)2	7.4492	11.5000	-4.0508
ZN2(OH)3	3.8898	15.2000	-11.3102
ZN5(OH)8	15.2287	38.5000	-23.2713
ZN2(OH)2	-2.1474	7.5000	-9.6474
ZN4(OH)6	12.7510	28.4000	-15.6490
ZNNO3)2,	-141.1517	3.2335	-144.3852
ZNO(ACT)	7.4492	11.3100	-3.8608
ZINCITE	7.4492	11.9591	-4.5099
ZN3O(SO4	-11.7439	21.3430	-33.0869
ZNS (A)	-60.2709	-45.1009	-15.1700
SPHALERI	-60.2709	-47.8425	-12.4284
WURTZITE	-60.2709	-45.7829	-14.4880
ZINCOSIT	-9.5966	3.7294	-13.3259
ZNSO4, 1	-9.5966	-.1713	-9.4252
BIANCHIT	-9.5966	-1.7540	-7.8426
GOSLARIT	-9.5966	-2.0836	-7.5130
CD METAL	-7.2562	14.1644	-21.4206
GAMMA CD	-7.2562	14.2697	-21.5258
OTAVITE	-15.4604	-13.7183	-1.7421
CDCL2	-16.6048	-.5125	-16.0923
CDCL2, 1	-16.6048	-1.6418	-14.9630
CDCL2,2.	-16.6049	-2.0041	-14.6008
CDF2	-20.3379	-2.6156	-17.7120
CD(O-)2	5.4124	13.6500	-8.2376
CDOHCL	-5.5967	3.7976	-9.3938
CD3(O-)4	-.8035	22.5600	-23.3635
CD3O-2(S	-17.8542	6.7100	-24.5642
CD4(O-)6	4.6039	28.4000	-23.7961
MONTEPON	5.4124	16.0477	-10.6353
CDSO4	-11.6333	.4523	-12.0856
CDSO4, 1	-11.6333	-1.3782	-10.2551
CDSO4,2	-11.6334	-1.7089	-9.9245
GREENOCK	-62.3077	-52.4563	-9.8513
ARSENOLI	-110.6439	-85.6154	-25.0285
CLAUDETI	-110.6439	-85.8364	-24.8075
ORIPMENT	-258.4823	-212.9550	-45.5272
REALGAR	-101.7154	-77.3724	-24.3429
AS2O3	-29.9848	6.9027	-36.8875
SULFUR	-55.0515	-37.8660	-17.1855
CA3(ASO4	.3021	22.3000	-21.9979
FEASO4.2	-2.1317	13.8047	-15.9364
MN3ASO42	-6.1045	12.5000	-18.6045
ZN3ASO42	-7.6372	13.6500	-21.2872
LIME	10.0957	34.5333	-24.4376
PORTLAND	10.0956	23.8199	-13.7243
WUSTITE	6.8520	12.6211	-5.7691
PERICLAS	9.4634	22.8657	-13.4024
MAG-FERR	35.1645	46.0763	-10.8919
LEPIDOCR	12.8677	14.7747	-1.9140
FE(O-)3F	12.8677	16.0747	-3.2147
NAFE13	-22.8831	5.0659	-27.9440
K2FE3	-28.6936	6.2913	-34.1857
CAFE3.2H	-19.6187	-3.5943	-16.0244
CAFE3.6-	-19.6187	-3.1350	-16.4837
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
CO2(GAS)	-20.8728	-18.1799	-2.6930
O2(GAS)	25.3372	88.2393	-62.9021
CAMOO4	-9.9446	-7.7462	-2.1984

DATA READ FROM DISK

Attachment B-3

Note: Modeling Tailings Pore Fluid w/ Cliff House Bkgrnd & Equilibration w/ min'ls expected along rxn path

11 continuous pages

L.M. COONS PE, PHE

OCT '90

10/1/90 (All B-3 pages were checked.)

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ELEMENTS
SPECIES
LOOK MIN
   'LIBRATION OF TAILINGS PORE FLUID/MW-605 MIX WITH EXPECTED MINERALS
0000010000 0 0          .00000
SOLUTION 1
2.5% TAILINGS PORE FLUID WITH CLIFF HOUSE BKGRND (MW-605)
16  0 0     6.63     -.496      10.5      1.00
   6  8.1100D-08  10  4.0700D-04  11  3.5300D-04  12  7.8100D-09  13  6.9800D-05
  16  9.6400D-07  17  9.4300D-08  19  1.2700D-05  21  8.1700D-05  22  2.5800D-06
  23  2.0200D-06  24  4.0600D-04  29  5.3000D-04  32  7.7800D-07  34  8.1700D-07
  35  5.1100D-07
MINERALS
URANINIT   2     4.00     -13.9      15.8        0                .000
  32   1.00       2   2.00
GOETHITE   4     3.00      13.5     -24.5        0                .000
   1  -3.00       3   2.00      17   1.00       2  -1.00
            0     .000      .000      .000        0                .000
NUMBER OF MINERALS FOUND   0
NUMBER OF MINERALS USED   2
SOLUTION NUMBER 1          2.5% TAILINGS PORE FLUID WITH CLIFF HOUSE BKGRND (MW-605)
```

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	8.1100000-08	-7.0910
C	4.0700000-04	-3.3904
CA	3.5300000-04	-3.4520
CD	7.8100000-09	-8.1073
CL	6.9800000-05	-4.1561
F	9.6400000-07	-6.0159
FE	9.4300000-08	-7.0255
H	1.2700000-05	-4.8962
MG	8.1700000-05	-4.0878
MN	2.5800000-06	-5.5864
N	2.0200000-06	-5.6946
NA	4.0600000-04	-3.3915
S	5.3000000-04	-3.2757
U	7.7800000-07	-6.1090
ZN	8.1700000-07	-6.0878
MO	5.1100000-07	-6.2916

See Attachment B-2

----DESCRIPTION OF SOLUTION----

```
                 pH =   6.8300
                 pe =   -.4957
          ACTIVITY H2O =   1.0000
       IONIC STRENGTH =    .0002
          TEMPERATURE =  10.0000
   ELECTRICAL BALANCE =  -1.2549D-04
                 TDS =   4.8108D-03
       TOTAL ALKALINITY =  3.9054D-04
           ITERATIONS =  15
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See Attachment B-2

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.55656D-07	-6.8078	1.47911D-07	-6.8300	9.50239D-01	-.0222
2	E-	-1.0	3.13112D+00	.4957	3.13112D+00	.4957	1.00000D+00	.0000
3	H2O	.0	9.99969D-01	-.0000	9.99969D-01	-.0000	1.00000D+00	.0000
6	H3ASO4	.0	1.01711D-15	-14.9926	1.01763D-15	-14.9924	1.00051D+00	.0000
10	CO3 2-	-2.0	7.51358D-08	-7.1242	6.12602D-08	-7.2128	8.15326D-01	-.0887
11	CA 2+	2.0	3.32336D-04	-3.4784	2.72690D-04	-3.5643	8.20525D-01	-.0859
12	CD 2+	2.0	6.93610D-09	-8.1589	5.65519D-09	-8.2476	8.15326D-01	-.0887
13	CL-	-1.0	6.97993D-05	-4.1561	6.62770D-05	-4.1786	9.49536D-01	-.0225
16	F-	-1.0	9.59435D-07	-6.0180	9.11692D-07	-6.0402	9.50239D-01	-.0222
17	FE 2+	2.0	9.01786D-08	-7.0449	7.35250D-08	-7.1336	8.15326D-01	-.0887
19	K+	1.0	1.26719D-05	-4.8972	1.20325D-05	-4.9196	9.49536D-01	-.0225
21	MG 2+	2.0	7.73754D-05	-4.1114	6.35882D-05	-4.1966	8.21815D-01	-.0852
22	MN 2+	2.0	2.44791D-06	-5.6112	1.99565D-06	-5.6999	8.15326D-01	-.0887
23	NO3 -	-1.0	0.00000D+00	-67.4482	0.00000D+00	-67.4704	9.50239D-01	-.0222
24	NA+	1.0	4.05199D-04	-3.3923	3.85159D-04	-3.4144	9.50544D-01	-.0220
29	SO4 2-	-2.0	5.04777D-04	-3.2969	4.11368D-04	-3.3856	8.14953D-01	-.0889
32	UO2 2+	2.0	4.86565D-11	-10.3129	3.96710D-11	-10.4015	8.15326D-01	-.0887
34	ZN 2+	2.0	7.54693D-07	-6.1221	6.15464D-07	-6.2108	8.15326D-01	-.0887
35	MOO4 2-	-2.0	5.11000D-07	-6.2916	4.16632D-07	-6.3802	8.15326D-01	-.0887
51	H3ASO3	.0	8.07973D-08	-7.0926	8.08388D-08	-7.0924	1.00051D+00	.0000
53	FE 3+	3.0	1.45732D-21	-20.8364	9.20556D-22	-21.0359	6.31678D-01	-.1995
55	NH4 +	1.0	2.00935D-06	-5.6969	1.90936D-06	-5.7191	9.50239D-01	-.0222
57	HS-	-1.0	1.11000D-25	-24.9546	1.05496D-25	-24.9766	9.50239D-01	-.0222
58	SO3 2-	-2.0	3.11000D-20	-19.5070	2.53690D-20	-19.5957	8.15326D-01	-.0887
60	U 4+	4.0	1.35066D-26	-25.8694	5.96749D-27	-26.2241	4.41902D-01	-.3547
61	UO2 +	1.0	1.05922D-07	-6.9750	1.00651D-07	-6.9972	9.50239D-01	-.0222
65	OH-	-1.0	2.26018D-08	-7.6459	2.14768D-08	-7.6680	9.50239D-01	-.0222
75	NH4SO4 -	-1.0	1.06483D-08	-7.9727	1.01164D-08	-7.9949	9.50239D-01	-.0222
76	MGO+ +	1.0	1.98114D-10	-9.7031	1.88256D-10	-9.7253	9.50239D-01	-.0222
77	MGF +	1.0	2.69318D-09	-8.5697	2.55916D-09	-8.5919	9.50239D-01	-.0222
78	MGCO3 AQ	.0	2.97403D-09	-8.5267	2.97555D-09	-8.5264	1.00051D+00	.0000
79	MGHCO3 +	1.0	1.98115D-07	-6.7031	1.88256D-07	-6.7253	9.50239D-01	-.0222
80	MGSO4 AQ	.0	4.10068D-06	-5.3850	4.10277D-06	-5.3846	1.00051D+00	.0000
84	CAO+ +	1.0	1.39708D-10	-9.8548	1.32756D-10	-9.8769	9.50239D-01	-.0222
85	CAHCO3 +	1.0	5.24564D-07	-6.2801	4.98576D-07	-6.3023	9.50239D-01	-.0222
86	CACO3 AQ	.0	1.84539D-06	-7.7339	1.84633D-06	-7.7337	1.00051D+00	.0000
87	CASO4 AQ	.0	2.01187D-05	-4.6964	2.01290D-05	-4.6962	1.00051D+00	.0000
91	CAF +	1.0	1.64703D-09	-8.7844	1.56032D-09	-8.8066	9.50239D-01	-.0222
92	NACO3 -	-1.0	2.13356D-10	-9.6709	2.02739D-10	-9.6931	9.50239D-01	-.0222
93	NAHCO3 A	.0	4.19349D-06	-7.3774	4.19584D-06	-7.3772	1.00051D+00	.0000
94	NASO4 -	-1.0	7.56706D-07	-6.1199	7.20952D-07	-6.1421	9.50239D-01	-.0222
96	NAF AQ	.0	5.69201D-11	-10.2447	5.69494D-11	-10.2445	1.00051D+00	.0000
97	KSO4 -	-1.0	2.80594D-08	-7.5519	2.66631D-08	-7.5741	9.50239D-01	-.0222
109	FEO+ +	1.0	5.29716D-11	-10.2760	5.03356D-11	-10.2981	9.50239D-01	-.0222
110	FEO+3 -1	-1.0	1.75093D-19	-18.7567	1.66380D-19	-18.7789	9.50239D-01	-.0222
111	FESO4 AQ	.0	4.06837D-09	-8.3906	4.07045D-09	-8.3904	1.00051D+00	.0000
113	FEOH2 AQ	.0	7.65553D-16	-15.1141	7.69347D-16	-15.1139	1.00051D+00	.0000
117	FEO+ 2+	2.0	2.00940D-17	-16.6969	1.63834D-17	-16.7856	8.15326D-01	-.0887
119	FESO4 +	1.0	2.36563D-21	-20.6261	2.24791D-21	-20.6482	9.50239D-01	-.0222
120	FECL 2+	2.0	1.39399D-24	-23.8557	1.13656D-24	-23.9444	8.15326D-01	-.0887
121	FECL2 +	1.0	5.74041D-28	-27.2411	5.45477D-28	-27.2632	9.50239D-01	-.0222
123	FEO2 +	1.0	2.20280D-14	-13.6570	2.09319D-14	-13.6792	9.50239D-01	-.0222
124	FEO2 AQ	.0	6.95249D-16	-15.1579	6.95650D-16	-15.1576	1.00051D+00	.0000
125	FEO4 -	-1.0	3.07920D-17	-16.5116	2.92600D-17	-16.5337	9.50239D-01	-.0222
127	FEF 2+	2.0	1.26956D-21	-20.8896	1.05141D-21	-20.9780	8.15326D-01	-.0887
128	FEF2 +	1.0	3.35769D-23	-22.4735	3.19280D-23	-22.4961	9.50239D-01	-.0222
129	FEF3 AQ	.0	4.37624D-26	-25.3589	4.37526D-26	-25.3589	1.00051D+00	.0000
130	FE(SO4)2	-1.0	2.69951D-23	-22.5577	2.75523D-23	-22.5556	9.50239D-01	-.0222
136	MNCL +	1.0	5.63193D-10	-9.2487	5.35162D-10	-9.2708	9.50239D-01	-.0222

139	MNOH +	1.0	1.05383D-10	-9.9772	1.00140D-10	-9.9994	9.50239D-01	-.0222
140	MN(OH)3	-1.0	1.02862D-20	-19.9877	9.77433D-21	-20.0099	9.50239D-01	-.0222
141	MNF +	1.0	1.35563D-11	-10.8679	1.28818D-11	-10.8900	9.50239D-01	-.0222
142	MNSO4 AQ	.0	1.23831D-07	-6.9072	1.23894D-07	-6.9069	1.00051D+00	.0002
144	MNHCO3 +	1.0	7.57658D-09	-8.1205	7.19956D-09	-8.1427	9.50239D-01	-.0222
162	ZNCL +	1.0	5.90021D-11	-10.2291	5.60661D-11	-10.2513	9.50239D-01	-.0222
163	ZNCL2 AQ	.0	3.65795D-15	-14.4368	3.65983D-15	-14.4365	1.00051D+00	.0002
164	ZNCL3 -	-1.0	2.61381D-19	-18.5827	2.48374D-19	-18.6049	9.50239D-01	-.0222
165	ZNCL4 2-	-2.0	8.94710D-24	-23.0483	7.29481D-24	-23.1370	8.15326D-01	-.0887
166	ZNF +	1.0	6.88735D-12	-11.1619	6.54463D-12	-11.1841	9.50239D-01	-.0222
167	ZNOH +	1.0	1.44322D-09	-8.8407	1.37140D-09	-8.8628	9.50239D-01	-.0222
168	ZN(OH)2	.0	5.89690D-11	-10.2294	5.89993D-11	-10.2292	1.00051D+00	.0002
169	ZN(OH)3	-1.0	6.37557D-16	-15.1955	6.05631D-16	-15.2176	9.50239D-01	-.0222
170	ZN(OH)4	-2.0	2.29857D-22	-21.6385	1.87409D-22	-21.7272	8.15326D-01	-.0887
171	ZNOHCL A	.0	9.12732D-12	-11.0397	9.13200D-12	-11.0394	1.00051D+00	.0002
174	ZNSO4 AQ	.0	5.27555D-08	-7.2777	5.27825D-08	-7.2775	1.00051D+00	.0002
175	ZN(SO4)2	-2.0	2.43414D-10	-9.6137	1.98462D-10	-9.7023	8.15326D-01	-.0887
180	ZNHCO3 +	1.0	7.38860D-19	-18.1314	7.02094D-19	-18.1536	9.50239D-01	-.0222
181	ZNCO3 AQ	.0	7.51922D-09	-8.1238	7.52306D-09	-8.1236	1.00051D+00	.0002
182	ZN(CO3)2	-2.0	1.20849D-11	-10.9178	9.85313D-12	-11.0064	8.15326D-01	-.0887
183	CDCL +	1.0	3.57990D-11	-10.4461	3.40176D-11	-10.4683	9.50239D-01	-.0222
184	CDCL2 AQ	.0	8.88155D-15	-14.0515	8.88611D-15	-14.0513	1.00051D+00	.0002
185	CDCL3 -	-1.0	3.10153D-19	-18.5084	2.94719D-19	-18.5306	9.50239D-01	-.0222
186	CDF +	1.0	6.83066D-14	-13.1655	6.49076D-14	-13.1877	9.50239D-01	-.0222
187	CDF2 AQ	.0	1.48567D-19	-18.8281	1.48643D-19	-18.8279	1.00051D+00	.0002
188	CD(CO3)3	-4.0	4.88267D-24	-23.3113	2.15766D-24	-23.6662	4.41902D-01	-.3547
189	CDOH +	1.0	1.08085D-12	-11.9662	1.02706D-12	-11.9884	9.50239D-01	-.0222
190	CD(OH)2	.0	1.15398D-15	-14.9378	1.15457D-15	-14.9376	1.00051D+00	.0002
191	CD(OH)3	-1.0	9.21667D-22	-21.0354	8.75804D-22	-21.0576	9.50239D-01	-.0222
192	CD(OH)4	-2.0	6.47236D-29	-28.1889	5.27759D-29	-28.2776	8.15326D-01	-.0887
193	CD2OH +3	3.0	5.44523D-20	-19.2640	3.43963D-20	-19.4635	6.31678D-01	-.1995
194	CDOHCL A	.0	6.86116D-14	-13.1636	6.86470D-14	-13.1634	1.00051D+00	.0002
196	CDSO4 AQ	.0	6.10927D-10	-9.2140	6.11240D-10	-9.2135	1.00051D+00	.0002
197	CDHS -	1.0	9.28646D-24	-23.0321	8.82436D-24	-23.0543	9.50239D-01	-.0222
205	CDHCO3 +	1.0	1.35454D-10	-9.8682	1.28714D-10	-9.8904	9.50239D-01	-.0222
206	CDCO3 AQ	.0	8.67767D-11	-10.0616	8.68312D-11	-10.0614	1.00051D+00	.0002
207	CD(SO4)2	-2.0	3.71173D-12	-11.4304	3.02627D-12	-11.5191	8.15326D-01	-.0887
265	H2AsO3 -	-1.0	1.93194D-10	-9.7140	1.83581D-10	-9.7362	9.50239D-01	-.0222
266	HAsO3 2-	-2.0	6.22693D-16	-15.2057	5.07698D-16	-15.2944	8.15326D-01	-.0887
267	AsO3 -3	-3.0	1.24276D-22	-21.9056	7.85225D-23	-22.1051	6.31678D-01	-.1995
268	H4AsO3 +	1.0	6.23428D-15	-14.2052	5.92406D-15	-14.2274	9.50239D-01	-.0222
269	H2AsO4 -	-1.0	4.78716D-11	-10.3199	4.54897D-11	-10.3421	9.50239D-01	-.0222
270	HAsO4 2-	-2.0	6.16211D-11	-10.2103	5.02413D-11	-10.2999	8.15326D-01	-.0887
271	AsO4 -3	-3.0	9.36651D-16	-15.0284	5.91662D-16	-15.2279	6.31678D-01	-.1995
272	HCO3 -	-1.0	2.89434D-04	-3.5385	2.75031D-04	-3.5606	9.50239D-01	-.0222
273	H2CO3 AQ	.0	1.16633D-04	-3.9332	1.16693D-04	-3.9330	1.00051D+00	.0002
274	HSO4 -	-1.0	4.19806D-09	-8.3770	3.98916D-09	-8.3991	9.50239D-01	-.0222
275	HF AQ	.0	1.47565D-10	-9.8310	1.47641D-10	-9.8308	1.00051D+00	.0002
276	HF2 -	-1.0	4.90210D-16	-15.3096	4.65817D-16	-15.3318	9.50239D-01	-.0222
277	H2F2 AQ	.0	1.06530D-19	-18.9725	1.06585D-19	-18.9723	1.00051D+00	.0002
281	H2S AQ	.0	2.42994D-25	-24.6144	2.43119D-25	-24.6142	1.00051D+00	.0002
283	UOH +3	3.0	5.13436D-21	-20.2895	3.24326D-21	-20.4890	6.31678D-01	-.1995
284	U(OH)2 +	2.0	3.89282D-16	-15.4097	3.17392D-16	-15.4984	8.15326D-01	-.0887
285	U(OH)3 +	1.0	3.19585D-12	-11.4954	3.03686D-12	-11.5176	9.50239D-01	-.0222
286	U(OH)4 A	.0	4.67673D-09	-8.3301	4.67913D-09	-8.3298	1.00051D+00	.0002
287	U(OH)5 -	-1.0	6.23512D-07	-6.2052	5.92486D-07	-6.2273	9.50239D-01	-.0222
288	UF +3	3.0	2.54141D-24	-23.5949	1.80535D-24	-23.7944	6.31678D-01	-.1995
289	UF2 2+	2.0	9.36552D-25	-24.0283	7.63594D-25	-24.1171	8.15326D-01	-.0887
290	UF3 +1	1.0	3.34773D-26	-25.4753	3.18114D-26	-25.4974	9.50239D-01	-.0222
291	UF4 AQ	.0	1.23991D-27	-26.9172	1.21253D-27	-26.9170	1.00051D+00	.0002
294	UCL +3	3.0	5.78936D-30	-29.2374	3.65701D-30	-29.4369	6.31678D-01	-.1995
295	USO4 2+	2.0	6.32708D-25	-24.1988	5.15864D-25	-24.2875	8.15326D-01	-.0887
296	U(SO4)2	.0	2.94047D-24	-23.5316	2.94197D-24	-23.5314	1.00051D+00	.0002
301	UO2OH +1	1.0	9.50274D-10	-9.0222	9.09957D-10	-9.0443	9.50239D-01	-.0222

303	UO2(SO4)5	1.0	2.72268D-14	-13.5650	2.58720D-14	-13.5872	9.50239D-01	-.0222
304	UO2CO3 A	.0	2.94451D-08	-7.5310	2.94602D-08	-7.5308	1.00051D+00	.0002
305	UO2(CO3)2	-2.0	1.33240D-08	-7.8754	1.08634D-08	-7.9640	8.15326D-01	-.0887
306	UO2(CO3)3	-4.0	1.06575D-10	-9.9723	4.70957D-11	-10.3270	4.41902D-01	-.3547
307	UO2F +1	1.0	5.03905D-12	-11.2977	4.78831D-12	-11.3198	9.50239D-01	-.0222
308	UO2F2 AQ	.0	2.96257D-14	-13.5283	2.96409D-14	-13.5281	1.00051D+00	.0002
309	UO2F3 -1	-1.0	7.87106D-18	-17.1040	7.47938D-18	-17.1261	9.50239D-01	-.0222
310	UO2F4 2-	-2.0	1.49537D-22	-21.8253	1.21922D-22	-21.9139	8.15326D-01	-.0887
311	UO2CL +1	1.0	4.12861D-15	-14.3842	3.92317D-15	-14.4064	9.50239D-01	-.0222
312	UO2SO4 A	.0	5.99468D-12	-11.2222	5.99776D-12	-11.2220	1.00051D+00	.0002
313	UO2SO4)2	-2.0	8.44957D-14	-13.0732	6.88916D-14	-13.1618	8.15326D-01	-.0887
353	HSO3-	-1.0	5.86627D-20	-19.2315	5.57626D-20	-19.2537	9.50239D-01	-.0222
354	H2SO3 AQ	.0	2.99173D-25	-24.5241	2.99327D-25	-24.5239	1.00051D+00	.0002

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-9.4101	-14.5120	5.1019
UO2 (AM	-9.4101	-8.5872	-.8229
U4O9 (C)	-24.9719	-41.6172	16.6453
U3O8 (C)	-2.8932	-6.0630	3.1698
UF4 (C)	-60.8907	-28.4019	-32.4888
UF4.2.5H	-60.8907	-38.0579	-22.8328
UO3 (C)	3.2585	8.4439	-5.1854
GUMMITE	3.2585	11.2621	-8.0037
B-UO2(O-	3.2584	6.0544	-2.7960
SCHOEPIT	3.2584	5.8515	-2.5931
RUTHERFO	-17.6143	-14.4467	-3.1677
ANHYDRIT	-6.9501	-4.4987	-2.4514
ARAGONIT	-10.7772	-8.2145	-2.5626
APATITE	-1.9461	10.6768	-12.6230
BRUCITE	9.4833	17.7582	-8.2948
CALCITE	-10.7772	-8.4078	-2.3693
DOLOMITE	-22.1866	-16.8394	-5.4472
EPSOMITE	-7.5825	-2.2457	-5.3368
FERRIHYD	12.8607	18.2947	-5.4340
FE3(OH)8	32.2479	47.0394	-14.7916
FEOH+2.7	9.5581	10.3647	-.8066
FES PPT	-61.1937	-39.8334	-21.3603
FECL(SO4)	-25.4158	32.6045	-58.0203
FLUORITE	-15.6446	-11.1365	-4.5087
GOETHITE	12.8607	14.4472	-1.5865
GREIGITE	-238.6326	-161.8740	-76.7585
GYPSUM	-6.9501	-4.8597	-2.0904
HALITE	-7.5930	1.5455	-9.1385
HEMATITE	25.7214	23.9653	1.7562
HUNTITE	-45.0055	-29.0048	-16.0007
HYDRMAGN	-36.1745	-6.8138	-29.3607
JAROSITE	4.4906	30.1904	-25.6999
MACKINAW	-61.1937	-40.5634	-20.6303
MAGHEMIT	25.7214	33.1994	-7.4779
MAGNESIT	-11.4094	-7.7988	-3.6106
MAGNETIT	32.2479	32.4400	-.1922
MELANTER	-10.5194	-2.5773	-7.9423
MIRABILI	-10.2146	-1.8815	-8.3331
NATRON	-14.0417	-1.8998	-12.1419
NESQUEHO	-11.4095	-5.4031	-6.0064
PYRITE	-116.0452	-90.7301	-25.5151
SIDERITE	-14.3484	-10.3503	-3.9981
THENARDI	-10.0145	-.1586	-10.0559
THERMONA	-14.0416	.2349	-14.2765
PYROLUSI	20.6287	43.4285	-22.7998
BIRNESSI	20.6287	44.5652	-23.9365

BIXBYITE	28.5888	52.9014	-24.3126
HAUSMANN	36.5489	64.5427	-27.9938
PYROCRO1	7.9601	15.9364	-7.9763
MANGANIT	14.2944	26.2352	-11.9408
RHODOCHR	-12.9127	-10.3321	-2.5806
MNCL2, 4	-14.0572	2.0586	-16.1160
MNS GREE	-59.7600	-31.8964	-27.8636
MNSO4	-9.0856	3.2500	-12.[illegible]
MN2(SO4)	-22.5485	48.6939	-71.2423
ZN METAL	-5.2194	27.1381	-32.3575
ZNCL2	-14.5681	7.6849	-22.2530
SMITHSON	-13.4236	-9.8366	-3.5870
ZNCO3, 1	-13.4236	-10.2600	-3.1636
ZNF2	-18.2911	-1.0299	-17.2612
ZN(OH)2	7.4492	11.5000	-4.0508
ZN2(OH)3	3.8898	15.2000	-11.3102
ZN5(OH)8	15.2287	38.5000	-23.2713
ZN2(OH)2	-2.1474	7.5000	-9.6474
ZN4(OH)6	12.7510	28.4000	-15.6490
ZNNO3)2,	-141.1517	3.2335	-144.3852
ZNO(ACTI	7.4492	11.3100	-3.8608
ZINCITE	7.4492	11.9591	-4.5099
ZN3O(SO4	-11.7439	21.3430	-33.0869
ZNS (A)	-60.2709	-45.1009	-15.1700
SPHALERI	-60.2709	-47.8425	-12.4284
WURTZITE	-60.2709	-45.7629	-14.4880
ZINCOSIT	-9.5966	3.7294	-13.3259
ZNSO4, 1	-9.5966	-.1713	-9.4252
BIANCHIT	-9.5966	-1.7540	-7.8426
GOSLARIT	-9.5966	-2.0838	-7.5130
CD METAL	-7.2562	14.1644	-21.4206
GAMMA CD	-7.2562	14.2697	-21.5259
OTAVITE	-15.4674	-13.7183	-1.7421
CDCL2	-16.6048	-.5125	-16.0923
CDCL2, 1	-16.6048	-1.6418	-14.9630
CDCL2,2.	-16.6048	-2.0041	-14.6009
CDF2	-20.3279	-2.6188	-17.7120
CD(OH)2	5.4134	13.6500	-8.2376
CDOHCL	-5.5962	3.7976	-9.3938
CD3(OH)4	-.8085	22.5600	-23.3685
CD3OH2(S	-17.8542	6.7100	-24.5642
CD4(OH)6	4.6039	28.4000	-23.7961
MONTEPON	5.4124	16.0477	-10.6353
CDSO4	-11.6333	.4523	-12.0856
CDSO4, 1	-11.6333	-1.3782	-10.2551
CDSO4,2.	-11.6334	-1.7089	-9.9245
GREENOCK	-62.3077	-52.4563	-9.8513
ARSENOLI	-110.6439	-85.6154	-25.0285
CLAUDETI	-110.6439	-85.8364	-24.8075
ORIPMENT	-256.4523	-212.9550	-45.5272
REALGAR	-101.7154	-77.3724	-24.3429
AS2O5	-29.9848	6.9027	-36.8875
SULFUR	-55.0515	-37.8660	-17.1855
CA3(ASO4	.3021	22.3000	-21.9979
FEASO4.2	-2.1317	13.8047	-15.9364
MN3ASO42	-6.1045	12.5000	-18.6045
ZN3ASO42	-7.6372	13.6500	-21.2872
LIME	10.0957	34.8333	-24.4376
PORTLAND	10.0956	23.8199	-13.7243
WUSTITE	6.8520	12.6211	-5.7691
FERICLAS	9.4634	22.8637	-13.4004
MAG-FERR	35.1848	46.0763	-10.8915
FERIDROX	10.8407	14.7747	-3.9340
FE(OH)3S	12.8607	16.0747	-3.2140
[illegible]	[illegible]	[illegible]	[illegible]

CASO3.2H	-19.6187	-3.5943	-16.0244
CASO3.5H	-19.6187	-3.1250	-16.4937
MGSO3	-20.2510	7.1898	-27.4408
CH4(GAS)	-71.5472	-43.3656	-28.1816
CO2(GAS)	-20.8728	-18.1799	-2.6930
O2(GAS)	25.3372	88.2393	-62.9021
CAMOO4	-9.9446	-7.7462	-2.1984

.P NUMBER 1

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY
AS	8.1100000D-08	-7.0910
C	4.0700000D-04	-3.3904
CA	3.5300000D-04	-3.4522
CD	7.8100000D-09	-8.1073
CL	6.9800000D-05	-4.1561
F	9.6400000D-07	-6.0159
FE	9.4300000D-08	-7.0255
K	1.2700000D-05	-4.8962
MG	8.1700000D-05	-4.0878
MN	2.5800000D-06	-5.5884
N	2.0200000D-06	-5.6946
NA	4.0600000D-04	-3.3915
S	5.3000000D-04	-3.2757
U	7.7800000D-07	-6.1090
ZN	8.1700000D-07	-6.0878
MO	5.1100000D-07	-6.2916

---- LOOK MIN IAP ----

PHASE	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-14.5120	-14.5120	.0000
UO2 (AM	-14.5120	-8.5872	-5.9248
U4O9 (C)	-45.3147	-41.6172	-3.6975
U3O8 (C)	-18.0694	-6.0630	-12.0063
UF4 (C)	-66.1222	-28.4019	-37.7203
UF4.2.5H	-66.1222	-38.0579	-28.0643
UO3 (C)	-1.7787	8.4439	-10.2226
GUMMITE	-1.7787	11.2621	-13.0408
B-UO2(OH	-1.7787	6.0544	-7.8331
SCHOEPIT	-1.7787	5.8515	-7.6302
RUTHERFO	-22.6748	-14.4467	-8.2281
AK-WORIT	-6.9505	-4.4987	-2.4517
ARAGONIT	-10.7359	-8.2145	-2.5213
ARTINITE	-1.8403	10.6768	-12.5171
BRUCITE	9.5079	17.7582	-8.2503
CALCITE	-10.7359	-8.4078	-2.3281
DOLOMITE	-22.1040	-16.6894	-5.4146
EPSOMITE	-7.5829	-2.2457	-5.3372
FERRIHYD	14.4471	18.0947	-3.6475
FE(OH)3A	36.9750	47.0394	-10.0644
FEO-HYD	11.1369	10.3647	.7722
[illegible]	[illegible]	[illegible]	[illegible]

FLUORITE	-15.6446	-11.1565	-4.5483
GOETHITE	14.4472	14.4472	.0000
GREIGITE	-235.2010	-161.8740	-73.3270
GYPSUM	-6.9505	-4.8597	-2.0908
HALITE	-7.5931	1.5455	-9.1386
HEMATITE	28.8945	23.9653	4.9292
HUNTITE	-44.8403	-29.0048	-15.8355
HYDRMAGN	-35.9447	-6.8136	-29.1310
JAROSITE	9.1202	30.1904	-21.0703
MACKINAW	-59.9635	-40.5634	-19.4001
MAGHEMIT	28.8945	33.1994	-4.3049
MAGNESIT	-11.3682	-7.7988	-3.5693
MAGNETIT	36.9750	32.4400	4.5350
MELANTER	-9.0303	-2.5772	-6.4531
MIRABILI	-10.2149	-1.8215	-8.3934
NATRON	-14.0003	-1.8998	-12.1006
NESQUEHO	-11.3682	-5.4031	-5.9651
PYRITE	-115.2741	-90.7301	-24.5441
SIDERITE	-12.8155	-10.3503	-2.4653
THENARDI	-10.2148	-.1586	-10.0562
THERMONA	-14.0002	.2349	-14.2351
PYROLUSI	20.7580	43.4285	-22.6705
BIRNESSI	20.7580	44.5652	-23.8072
NSUTITE	20.7580	43.9752	-23.2172
BIXBYITE	28.7827	52.9014	-24.1187
HAUSMANN	36.8274	64.[illegible]7	-27.7353
PYROCROI	8.0247	15.9364	-7.9117
MANGANIT	14.3913	26.2352	-11.8439
RHODOCHR	-12.8714	-10.3321	-2.5394
MNCL2, 4	-14.0574	2.0588	-16.1162
MNS GREE	-60.0193	-31.8964	-28.1229
MNSO4	-9.0860	3.2500	-12.3360
MN2(SO4)	-22.5495	48.6939	-71.2434
ZN METAL	-5.2200	27.1381	-32.3581
ZNCL2	-14.5687	7.6849	-22.2537
SMIT-SON	-13.3528	-9.8366	-3.5461
ZNCO3, 1	-13.3528	-10.2600	-3.1228
ZNFE	-18.2917	-1.0299	-17.2618
ZN(OH)2	7.5133	11.5000	-3.9867
ZN2(OH)3	3.9857	15.2000	-11.2143
ZN5(OH)8	15.4646	38.5000	-23.0354
ZN2(OH)2	-2.0840	7.5000	-9.5840
ZN4(OH)6	12.9426	28.4000	-15.4574
ZNNO3(2)	-140.5050	3.2335	-143.7385
ZNO(ACT)	7.5134	11.3100	-3.7966
ZINCITE	7.5134	11.9591	-4.4457
ZN3O(SO4	-11.6814	21.3430	-33.0244
ZNS (A)	-60.5307	-45.1009	-15.4298
SPHALERI	-60.5307	-47.8425	-12.6882
WURTZITE	-60.5307	-45.7829	-14.7477
ZINCOSIT	-9.5974	3.7294	-13.3268
ZNSO4, 1	-9.5974	-.1713	-9.4261
BIANCHIT	-9.5975	-1.7540	-7.8434
GOSLARIT	-9.5975	-2.0636	-7.5339
CO METAL	-7.2569	14.1644	-21.4213
GAMMA CO	-7.2569	14.2697	-21.5266
COAVITE	-15.4197	-13.7183	-1.7014
[illegible]	-16.6057	-.5109	-16.0931
COCL2, 1	-16.6057	-1.6418	-14.9639
COCL2(C	-16.6057	-2.0041	-14.6016
COF2	-20.3387	-3.6158	-17.7229
CO(OH)2	5.4764	13.6500	-8.1736
CO-CL	-5.5646	3.7976	-9.3623
CO3(OH)4	-1.6815	22.5600	-23.2415
[illegible]	[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]	[illegible]
MONTEPON	5.4764	16.0477	-10.5713
CDSO4	-11.6343	.4523	-12.0866
CDSO4, 1	-11.6343	-1.3782	-10.2561
CDSO4,2.	-11.6344	-1.7089	-9.9255
GREENOCK	-62.5676	-52.4563	-10.1113
ARSENOLI	-110.6449	-85.6154	-25.0295
CLAUDETI	-110.6449	-85.8364	-24.8085
ORIPMENT	-259.4545	-212.9550	-46.4995
REALGAR	-102.0719	-77.3724	-24.6995
AS2O5	-29.8558	6.9027	-36.7585
SULFUR	-55.3107	-37.8660	-17.4447
CA3(ASO4	.6249	22.3000	-21.6751
FEASO4.2	-.4807	13.8047	-14.2854
MN3ASO42	-5.7818	12.5000	-18.2818
ZN3ASO42	-7.3158	13.6500	-20.9658
LIME	10.1603	34.5333	-24.3730
PORTLAND	10.1602	23.8199	-13.6597
WUSTITE	8.3272	12.6211	-4.2939
PERICLAS	9.5280	22.8637	-13.3356
MAG-FERR	38.4224	46.0763	-7.6538
LEPIDOCR	14.4472	14.7747	-.3275
FE(OH)3S	14.4472	16.0747	-1.6275
NA2SO3	-22.9481	5.0609	-28.0090
K2SO3	-25.9587	8.2917	-34.2504
CASO3.2H	-19.6838	-3.5943	-16.0895
CASO3.5H	-19.6838	-3.1250	-16.5588
MGSO3	-20.3161	7.1898	-27.5059
CH4(GAS)	-71.6294	-43.3656	-28.4639
CO2(GAS)	-20.8961	-18.1799	-2.7163
O2(GAS)	25.4666	88.2393	-62.7727
CAMOO4	-9.9449	-7.7462	-2.1988

----PHASE BOUNDARIES----

PHASE	DELTA PHASE*	LOG IAP	LOG KT	LOG IAP/KT
URANINIT	-7.7799340-07	-14.5120	-14.5120	.0000
GOETHITE	2.8169120-06	14.4472	14.4472	.0000

* NEGATIVE DELTA PHASE INDICATES PRECIPITATION AND POSITIVE DELTA PHASE INDICATES DISSOLUTION

TOTAL MOLALITIES OF ELEMENTS

ELEMENT	MOLALITY	LOG MOLALITY	mg/l
AS	8.1100000-08	-7.0910	6×10^{-3}
C	4.0700000-04	-3.3904	
CA	3.5300000-04	-3.4522	
CD	7.8100000-09	-8.1073	8×10^{-4}
CL	6.9800000-05	-4.1561	
F	9.6400000-07	-6.0159	
FE	2.9112120-06	-5.5359	
K	1.2700000-05	-4.8962	
MG	8.1700000-05	-4.0878	
MN	2.5800000-06	-5.5884	
N	2.0200000-06	-5.6949	2.8×10^{-2}
NA	4.0600000-04	-3.3915	
S	5.3000000-04	-3.0757	
→ U	6.5817390-12	-11.1817	1.6×10^{-6} $\boxed{1.6\ mg/l}$
ZN	8.1700000-07	-6.0878	5.3×10^{-2}
MO	5.1100000-07	-6.2918	4.9×10^{-2}

----DESCRIPTION OF SOLUTION----

PH =	6.8624
PE =	-.4957
ACTIVITY H2O =	1.0000
IONIC STRENGTH =	.0022
TEMPERATURE =	10.5000
ELECTRICAL BALANCE =	-1.2549D-04
THOR =	4.8131D-03
TOTAL ALKALINITY =	2.9659D-04
ITERATIONS =	18

DISTRIBUTION OF SPECIES

I	SPECIES	Z	MOLALITY	LOG MOLALITY	ACTIVITY	LOG ACTIVITY	GAMMA	LOG GAMMA
1	H+	1.0	1.44489D-07	-6.8402	1.37268D-07	-6.8624	9.50159D-01	-.0222
2	E-	-1.0	3.13112D-00	.4957	3.13112D+00	.4957	1.00000D+00	.0000
3	H2O	.0	9.99969D-01	-.0000	9.99969D-01	-.0000	1.00000D+00	.0000
6	H3ASO4	.0	1.17990D-15	-14.9282	1.18051D-15	-14.9279	1.00051D+00	.0002
10	CO3 2-	-2.0	8.26839D-08	-7.0826	6.73916D-08	-7.1714	8.15050D-01	-.0888
11	CA 2+	2.0	3.32341D-04	-3.4784	2.72607D-04	-3.5645	8.20264D-01	-.0860
12	CD 2+	2.0	6.92634D-09	-8.1595	5.64532D-09	-8.2483	8.15050D-01	-.0888
13	CL-	-1.0	6.97973D-05	-4.1561	6.62712D-05	-4.1787	9.49453D-01	-.0225
16	F-	-1.0	9.59452D-07	-6.0180	9.11631D-07	-6.0402	9.50159D-01	-.0222
17	FE 2+	2.0	2.78396D-06	-5.5553	2.26907D-06	-5.6442	8.15050D-01	-.0888
19	K+	1.0	1.26720D-05	-4.8972	1.20314D-05	-4.9197	9.49453D-01	-.0225
21	MG 2+	2.0	7.73745D-05	-4.1114	6.35676D-05	-4.1968	8.21557D-01	-.0854
22	MN 2+	2.0	2.44766D-06	-5.6117	1.99513D-06	-5.7000	8.15050D-01	-.0888
23	NO3 -	-1.0	0.00000D+00	-67.1246	0.00000D+00	-67.1468	9.50159D-01	-.0222
24	NA+	1.0	4.05199D-04	-3.3923	3.85127D-04	-3.4144	9.50464D-01	-.0221
29	SO4 2-	-2.0	5.04677D-04	-3.2970	4.11146D-04	-3.3860	8.14670D-01	-.0890
32	UO2 2+	2.0	3.84959D-16	-15.4146	3.13761D-16	-15.5034	8.15050D-01	-.0888
34	ZN 2+	2.0	7.54279D-07	-6.1226	6.14653D-07	-6.2114	8.15050D-01	-.0888
35	MOO4 2-	-2.0	5.11000D-07	-6.2916	4.16491D-07	-6.3804	8.15050D-01	-.0888
51	H3ASO3	.0	8.07491D-08	-7.0909	8.07907D-08	-7.0926	1.00051D+00	.0002
53	FE 3+	3.0	4.50992D-20	-19.3467	2.84095D-20	-19.5465	6.31197D-01	-.1998
55	NH4 +	1.0	2.00936D-06	-5.6969	1.90921D-06	-5.7191	9.50159D-01	-.0222
57	HS-	-1.0	5.67396D-26	-25.2441	5.39116D-26	-25.2663	9.50159D-01	-.0222
58	SO3 2-	-2.0	2.68088D-20	-19.5719	2.18440D-20	-19.6607	8.15050D-01	-.0888
61	UO2 +	1.0	8.37816D-13	-12.0769	7.96058D-13	-12.0991	9.50159D-01	-.0222
65	OH-	-1.0	2.43524D-08	-7.6135	2.31367D-08	-7.6357	9.50159D-01	-.0222
75	NH4SO4 -	-1.0	1.06426D-08	-7.9730	1.01121D-08	-7.9952	9.50159D-01	-.0222
76	MGOH +	1.0	2.13393D-10	-9.6708	2.02757D-10	-9.6930	9.50159D-01	-.0222
77	MGF +	1.0	2.69235D-09	-8.5699	2.55816D-09	-8.5921	9.50159D-01	-.0222
78	MGCO3 AQ	.0	3.27062D-09	-8.4854	3.27230D-09	-8.4851	1.00051D+00	.0002
79	MGHCO3 +	1.0	2.02242D-07	-6.6941	1.92162D-07	-6.7163	9.50159D-01	-.0222
80	MGSO4 AQ	.0	4.11709D-06	-5.3854	4.11921D-06	-5.3852	1.00051D+00	.0002
84	CAO- +	1.0	1.50485D-10	-9.8225	1.42985D-10	-9.8447	9.50159D-01	-.0222
85	CAHCO3 +	1.0	5.35624D-07	-6.2711	5.08927D-07	-6.2933	9.50159D-01	-.0222
86	CACO3 AQ	.0	2.02946D-08	-7.6926	2.03058D-08	-7.6924	1.00051D+00	.0002
87	CASO4 AQ	.0	2.01016D-05	-4.6968	2.01120D-05	-4.6965	1.00051D+00	.0002
91	CAF +	1.0	1.64155D-09	-8.7847	1.55974D-09	-8.8069	9.50159D-01	-.0222
92	NACO3 -	-1.0	2.34710D-10	-9.6295	2.23012D-10	-9.6517	9.50159D-01	-.0222
93	NAHCO3 AQ	.0	4.28171D-08	-7.3654	4.28391D-08	-7.3680	1.00051D+00	.0002
94	NASO4 -	-1.0	7.58297D-07	-6.1202	7.20503D-07	-6.1424	9.50159D-01	-.0222
95	NAF AQ	.0	5.69114D-11	-10.2449	5.69407D-11	-10.2446	1.00051D+00	.0002
97	KSO4 -	-1.0	2.80447D-08	-7.5520	2.66465D-08	-7.5744	9.50159D-01	-.0222
109	FEO+ +	1.0	1.76141D-09	-8.7541	1.67362D-09	-8.7763	9.50159D-01	-.0222
110	FEO+ -1	-1.0	6.78810D-18	-17.1707	6.47127D-18	-17.1904	9.50159D-01	-.0222

113	FEOH2 AQ	.0	2.75454D-14	-13.5603	2.75376D-14	-13.5607	[illegible]	.0002
117	FEOH 2+	2.0	6.68344D-16	-15.1750	5.44734D-16	-15.2638	8.15050D-01	-.0888
119	FESO4 +	1.0	7.29730D-20	-19.1368	6.93359D-20	-19.1590	9.50159D-01	-.0222
120	FECL 2+	2.0	4.30310D-23	-22.3662	3.50724D-23	-22.4550	8.15050D-01	-.0888
121	FECL2 +	1.0	1.77140D-26	-25.7517	1.68311D-26	-25.7739	9.50159D-01	-.0222
123	FEOH2 +	1.0	7.89154D-13	-12.1028	7.49822D-13	-12.1250	9.50159D-01	-.0222
124	FEOH3 AQ	.0	2.68323D-14	-13.5713	2.68461D-14	-13.5711	1.00051D+00	.0002
125	FEOH4 -	-1.0	1.28046D-15	-14.8926	1.21664D-15	-14.9148	9.50159D-01	-.0222
127	FEF 2+	2.0	3.98081D-20	-19.4000	3.24456D-20	-19.4888	8.15050D-01	-.0888
128	FEF2 +	1.0	1.03623D-21	-20.9845	9.84585D-22	-21.0067	9.50159D-01	-.0222
129	FEF3 AQ	.0	1.35022D-24	-23.8696	1.35092D-24	-23.8694	1.00051D+00	.0002
130	FE(SO4)2	-1.0	8.93936D-22	-21.0487	8.49381D-22	-21.0709	9.50159D-01	-.0222
131	FE2(OH)2	4.0	3.39685D-29	-28.4689	1.49904D-29	-28.8242	4.41304D-01	-.3553
136	MNCL +	1.0	5.62988D-10	-9.2495	5.34928D-10	-9.2717	9.50159D-01	-.0222
137	MNCL2 AQ	.0	9.62491D-15	-14.0166	9.62986D-15	-14.0164	1.00051D+00	.0002
138	MNCL3 -	-1.0	3.02795D-19	-18.5189	2.87703D-19	-18.5411	9.50159D-01	-.0222
139	MNOH +	1.0	1.13507D-10	-9.9450	1.07849D-10	-9.9672	9.50159D-01	-.0222
140	MN(OH)3	-1.0	1.28600D-20	-19.8908	1.22190D-20	-19.9130	9.50159D-01	-.0222
141	MNF +	1.0	1.35517D-11	-10.8680	1.28763D-11	-10.8902	9.50159D-01	-.0222
142	MNSO4 AQ	.0	1.23719D-07	-6.9076	1.23783D-07	-6.9073	1.00051D+00	.0002
144	MNHCO3 +	1.0	7.73413D-09	-8.1116	7.34865D-09	-8.1338	9.50159D-01	-.0222
162	ZNCL +	1.0	5.89223D-11	-10.2297	5.59856D-11	-10.2519	9.50159D-01	-.0222
163	ZNCL2 AQ	.0	3.65237D-15	-14.4374	3.65425D-15	-14.4372	1.00051D+00	.0002
164	ZNCL3 -	-1.0	2.60962D-19	-18.5834	2.47974D-19	-18.6056	9.50159D-01	-.0222
165	ZNCL4 2-	-2.0	8.93493D-24	-23.0489	7.28242D-24	-23.1377	8.15050D-01	-.0888
166	ZNF +	1.0	6.87618D-12	-11.1625	6.53536D-12	-11.1847	9.50159D-01	-.0222
167	ZNOH +	1.0	1.55293D-09	-8.8088	1.47553D-09	-8.8311	9.50159D-01	-.0222
168	ZN(OH)2	.0	6.83556D-11	-10.1652	6.83908D-11	-10.1650	1.00051D+00	.0002
169	ZN(OH)3	-1.0	7.96297D-16	-15.0989	7.56608D-16	-15.1211	9.50159D-01	-.0222
170	ZN(OH)4	-2.0	3.09381D-22	-21.5095	2.52161D-22	-21.5983	8.15050D-01	-.0888
171	ZNOHCL A	.0	9.81943D-12	-11.0079	9.82449D-12	-11.0077	1.00051D+00	.0002
174	ZNSO4 AQ	.0	5.26558D-08	-7.2786	5.26629D-08	-7.2763	1.00051D+00	.0002
175	ZN(SO4)2	-2.0	2.42906D-10	-9.6146	1.97981D-10	-9.7034	8.15050D-01	-.0888
180	ZNHCO3 +	1.0	7.53478D-19	-18.1229	7.15924D-19	-18.1451	9.50159D-01	-.0222
181	ZNCO3 AQ	.0	8.26361D-09	-8.0830	8.26467D-09	-8.0826	1.00051D+00	.0002
182	ZN(CO3)2	-2.0	1.46102D-11	-10.8353	1.19051D-11	-10.9242	8.15050D-01	-.0888
183	CDCL +	1.0	3.57364D-11	-10.4469	3.39552D-11	-10.4691	9.50159D-01	-.0222
184	CDCL2 AQ	.0	8.66449D-15	-14.0603	8.66905D-15	-14.0621	1.00051D+00	.0002
185	CDCL3 -	-1.0	3.09557D-19	-18.5093	2.94128D-19	-18.5315	9.50159D-01	-.0222
186	CDF +	1.0	6.81885D-14	-13.1663	6.47899D-14	-13.1885	9.50159D-01	-.0222
187	CDF2 AQ	.0	1.48287D-19	-18.8289	1.48363D-19	-18.8287	1.00051D+00	.0002
188	CD(CO3)3	-4.0	6.49761D-24	-23.1872	2.86751D-24	-23.5425	4.41304D-01	-.3553
189	CDOH +	1.0	1.16255D-12	-11.9346	1.10461D-12	-11.9568	9.50159D-01	-.0222
190	CD(OH)2	.0	1.33713D-15	-14.8738	1.33762D-15	-14.8736	1.00051D+00	.0002
191	CD(OH)3	-1.0	1.15069D-21	-20.9390	1.09334D-21	-20.9612	9.50159D-01	-.0222
192	CD(OH)4	-2.0	8.70814D-29	-28.0601	7.09757D-29	-28.1489	8.15050D-01	-.0888
193	CD2OH +3	3.0	5.85057D-20	-19.2328	3.69286D-20	-19.4326	6.31197D-01	-.1998
194	CDOHCL A	.0	7.37853D-14	-13.1320	7.38233D-14	-13.1318	1.00051D+00	.0002
196	CDSO4 AQ	.0	6.09531D-10	-9.2150	6.09844D-10	-9.2148	1.00051D+00	.0002
197	CDHS +	1.0	4.73760D-24	-23.3244	4.50166D-24	-23.3466	9.50159D-01	-.0222
205	CDHCO3 +	1.0	1.38079D-10	-9.8599	1.31197D-10	-9.8821	9.50159D-01	-.0222
206	CDCO3 AQ	.0	9.52951D-11	-10.0209	9.53441D-11	-10.0207	1.00051D+00	.0002
207	CD(SO4)2	-2.0	3.70252D-12	-11.4315	3.01774D-12	-11.5203	8.15050D-01	-.0888
265	HZASO3 -	-1.0	2.08037D-10	-9.6819	1.97668D-10	-9.7041	9.50159D-01	-.0222
266	HASO3 2-	-2.0	7.27603D-16	-15.1411	5.88958D-16	-15.2299	8.15050D-01	-.0888
267	ASO3 -3	-3.0	1.55441D-22	-21.8084	9.81141D-23	-22.0083	6.31197D-01	-.1998
268	H4ASO3 +	1.0	5.78357D-15	-14.2378	5.49531D-15	-14.2600	9.50159D-01	-.0222
269	HZASO4 -	-1.0	5.96362D-11	-10.2230	5.68539D-11	-10.2452	9.50159D-01	-.0222
270	HASO4 2-	-2.0	8.30029D-11	-10.0809	6.76515D-11	-10.1697	8.15050D-01	-.0888
271	ASO4 -3	-3.0	1.35986D-15	-14.8665	8.58339D-16	-15.0663	6.31197D-01	-.1998
272	HCO3 -	-1.0	2.95559D-04	-3.5294	2.80878D-04	-3.5516	9.50159D-01	-.0222
273	HZCO3 AQ	.0	1.10536D-04	-3.9565	1.10594D-04	-3.9563	1.00051D+00	.0002
274	HSO4 -	-1.0	3.69476D-09	-8.4095	3.70066D-09	-8.4317	9.50159D-01	-.0222
275	HF AQ	.0	1.36958D-10	-9.8634	1.37028D-10	-9.8637	1.00051D+00	.0002
276	HF2 -	-1.0	4.54760D-16	-15.3420	4.32303D-16	-15.3642	9.50159D-01	-.0222
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

L.M. COONS PE, PHG

OCT '90

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. DUR-Ø9-90-13-06-00 DISCIPLINE Geochemistry NO. OF SHEETS 5

PROJECT: UMTRA

SITE: DURØ3
Bodo Canyon

FEATURE: Attenuation of Vanadium by subpile sediments

SOURCES OF DATA:
Analytical data - Dart System
Sediment thickness - Attachment B, Data from Bodo Can. Geotech.
Sediment density - Bodo Canyon Geotechnical Report; UMTRA Project
Prepared by Dames & Moore, 1983.

SOURCES OF FORMULAE & REFERENCES:
Experience:

(1) $V = \text{length} \times \text{width} \times \text{height}$

(2) $C_{v,sed} = \frac{(C_o - C_f) V_l}{m_{sed}}$

C_o = initial conc. in batch test
C_f = final conc. in batch test
V_l = liquid vol. in batch test
m_{sed} = mass of sed in batch test

PRELIMINARY CALC. ☐ FINAL CALC. ☒ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		W.F. Downs	Ø9/24/90	[illegible]	10/01/90	[illegible]	10/2/90

8/86

L.M. COONS PE, PHE

OCT '90

9/26/90

10/1/90

CALC. SET: DUR-09-90-13-06-00

A. Purpose of Calculation

This calculation set is designed to determine the attenuation capacity of the subpile sediments for vanadium.

B. Method and Procedures

A series of sediment attenuation batch tests were performed in accordance with ASTM Method 4319 in which 200 g of sediment was reacted with 800 ml of tailings pore fluid for a total of 72 hours. During the experiment, the slurry was agitated for one hour in every 12. At the conclusion of the experiment, the slurry was filtered and the filtrate was submitted for analysis. The tailings fluids used in these experiments were collected from the toe drain in the Bodo Canyon tailings embankment. The loading of the subpile sediments was calculated by considering the mass of vanadium that could be attenuated by a column of sediment 1cm x 1cm x 914cm and a loading factor of 0.030 mg/g of sediment. MPHO

C. ASSUMPTIONS

1. The fluid samples from the Bodo Canyon toe drain are true representations of the tailings pore fluids. valid for

2. The batch tests were of sufficient duration to allow the system to come to equilibrium. valid for

3. The subpile sediment samples are true representatives of the vadose zone beneath the Bodo Canyon tailings embankment. valid for

D. MATERIAL PROPERTIES

Attachment A is a listing of the influent and effluent concentrations of major, minor and trace constituents for each of the batch tests.

E. DATA SOURCES

The data used in this calculation were derived from the various geotechnical reports and from the DART data base.

F. CALCULATION AND ANALYSIS

C_o = Conc. of vanadium in the test fluid (mg/l)

C_f = Conc. of V in the batch test leachate (mg/l)

Batch Tests:

Volume of liquid: 0.800 l (V_l) C_o: 13.6 mg/l

Mass of solid: 200 g (m_{sed}) C_f: 6.0 mg/l

$$\text{Conc. of V on sed.} = \frac{(C_o - C_f)\,V_l}{m_{sed}} = \frac{(13.5 - 6.0)\text{mg/l}\ (0.8\ \text{l})}{200\ \text{g}}$$

$$= 0.030\ \text{mg/g}$$

Soil Column: (30 ft or 914 cm high by 1 cm^2 in area) : see Attachment B

mass = density x volume = 1.60 g/cm^3 (914 x 1 x 1)cm^3

= 1463 g (1462.4) REFERENCE: Dames & Moore; 1983.

Mass of V sorbed in sed column:

m_V = 0.030 mg/g (1463 g) = 43.9 mg

Volume of fluid required for loading:

$$V_f = \frac{43.9\ \text{mg V}}{10.5\ \text{mg V/l}} = 4.2\ \text{l}$$

L.M. COOKS FILE
OCT '90

DUR-10-90-12-05

Based upon the anticipated fluid flux through the cover and the transient drainage, it is estimated that each square cm area beneath the tailings embankment will be exposed to 0.23 l of fluid. The subpile sediment column has the capacity to sorb the vanadium from approximately 18 times the amount of fluid to which it will be exposed. In addition, there will be a component of dilution from the liquid contained within the vadose zone that will decrease the concentration of the solutions entering the groundwater.

G. CONCLUSIONS

The subpile sediments have sufficient attenuation capacity to remove up to 18 times the amount of vanadium to which they are expected to be exposed.

Attachment A

INFLUENT AND EFFLUENT CONCENTRATIONS

3

Attenuation Factors for Bodo Canyon Supply Sediments

BH →

Species	SA 707 INFLUENT	SA 699	Ratio OUT/IN	SA 700 MG/CL	Ratio OUT/IN	SA 701	RA710 OUT/IN	SA 702 MG/ML	RA710 OUT/IN
		645		648		620		623	
Alk		453.000		492.000		490.000		493.000	
Ag	0.010	0.010	1.000	0.010	1.0000	0.010	1.0000	DL 0.01	0.0000
Al	0.100	DL 0.1	0.000	DL 0.1	0.0000	DL 0.1	0.0000	DL 0.1	0.0000
As	0.342	0.040	0.117	0.080	0.2339	0.036	0.1053	0.110	0.3216
B	0.300	0.200	0.667	0.200	0.6667	0.200	0.6667	0.200	0.6667
Ba	DL 0.1	0.200	ERR	DL 0.1	ERR	0.100	ERR	0.100	ERR
Be	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
Br	DL 0.1	DL 0.1	ERR	DL 0.01	ERR	DL 0.1	ERR	0.200	ERR
Ca	566.000	541.000	0.956	531.000	0.9382	502.000	0.886	495.000	0.8746
Cd	0.019	0.003	0.158	0.007	0.3684	0.004	0.2105	0.007	0.3684
Cl	70.000	73.000	1.043	69.000	0.9857	69.000	0.9857	69.000	0.9857
Co	0.160	DL 0.05	0.000	0.060	0.3750	DL 0.05	0.0000	DL 0.05	0.0000
Cr	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
Cu	0.030	DL 0.02	0.000	DL 0.02	0.0000	DL 0.02	0.0000	0.000	0.0000
DOC	65.000	0.000	0.000	123.000	1.8923	50.000	0.7692	53.000	0.8154
F	0.700	0.800	1.143	0.700	1.0000	0.700	1.0000	0.700	1.0000
Fe	0.130	0.090	0.692	0.090	0.6923	0.090	0.6923	0.090	0.6923
Hg	DL 0.00002	0.0002	ERR	DL 0.0002	ERR	DL 0.0002	ERR	DL 0.0002	ERR
K	17.600	7.600	0.432	12.700	0.7216	14.300	0.8125	11.800	0.6705
Mg	61.600	94.700	1.538	100.000	1.6181	109.000	1.7695	110.000	1.7857
Mn	4.460	0.340	0.076	2.660	0.5964	2.460	0.5516	2.350	0.5269
Mo	1.690	1.600	0.947	1.600	0.9467	1.620	0.9586	1.610	0.9527
Na	235.000	234.000	0.983	245.000	1.0294	236.000	0.9916	235.000	0.9874
N	0.060	DL 0.04	0.000	DL 0.04	0.0000	DL 0.04	0.0000	DL 0.04	0.0000
NO3	DL 0.1	DL 0.1	ERR	DL 0.1	ERR	DL 0.1	ERR	DL 0.1	ERR
Pb	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
pH	7.000	7.800	1.117	7.270	1.0386	7.390	1.0557	7.170	1.0243
PO4	3.300	0.900	0.273	1.200	0.3636	0.600	0.1818	2.000	0.6061
ReO4	14.000	0.800	0.036	0.800	0.0571	0.700	0.0500	0.700	0.0500
ReO2	1.000	1.600	1.600	0.800	2.0000	3.700	3.7000	3.400	3.4000
Sb	DL 0.003	DL 0.003	ERR	0.006	ERR	DL 0.003	ERR	0.008	ERR
Se	0.593	0.365	0.699	0.074	0.7957	0.035	0.3763	0.041	0.4459
SOD	51.000	32.000	0.627	46.000	0.9020	43.000	0.8431	47.000	0.9216
Sr	0.029	0.006	0.207	0.018	0.6207	0.012	0.4138	0.012	0.4138
SO4	1770.000	1740.000	0.983	1730.000	0.9774	1700.000	0.9605	1750.000	0.9887
Sr	2.810	2.270	0.808	2.710	0.9644	2.510	0.8932	2.770	0.9858
TDS	3200.000	2970.000	0.928	3060.000	0.9563	3030.000	0.9469	3050.000	0.9531
Tl	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
U	4.000	3.290	0.823	3.120	0.7800	3.080	0.7700	3.460	0.8650
V	13.600	2.110	0.155	5.940	0.4368	3.310	0.2434	6.040	0.4441
Zn	1.180	0.104	0.088	2.130	1.8051	2.2500	1.9068	0.358	0.3034

9/26/90

10/1/90

LAB COORDINATE PH2

30

ATTACHMENT A (CONCLUDED)

Attenuation factors for the Bear Canyon sample sediments (ppm dry sample wt.)

BH →

Species	SA 702 INFLUENT	SA 703 SC	Ratio OUT/IN	SA 704 ML/CL	Ratio OUT/IN	SA 705 CL	RATIO OUT/IN	SA 706 CL/ML	RATIO OUT/IN
		645		646		620		623	
Al		438.000		470.000		453.000		457.000	
As	DL 0.01	0.010	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
A	0.200	DL 0.1	0.000	DL 0.1	0.0000	DL 0.1	0.0000	DL 0.1	0.0000
Ag	0.269	0.080	0.2970	0.033	0.1227	0.070	0.2602	0.050	0.1859
B	0.200	0.200	1.000	0.200	1.0000	0.200	1.0000	0.200	1.0000
Ba	DL 0.1	0.200	ERR	DL 0.1	ERR	0.100	ERR	0.100	ERR
Be	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
Br	DL 0.1	DL 0.1	ERR	DL 0.01	ERR	DL 0.1	ERR	DL 0.1	ERR
Ca	583.000	539.000	0.925	487.000	0.8353	512.000	0.8782	479.000	0.8216
Cd	0.020	0.005	0.250	0.003	0.1500	0.005	0.2500	0.002	0.1000
Cl	70.000	73.000	1.043	69.000	0.9857	69.000	0.9857	69.000	0.9857
Co	0.160	DL 0.05	0.000	DL 0.05	0.0000	DL 0.05	0.0000	DL 0.05	0.0000
Cr	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
Cu	0.030	DL 0.02	0.000	DL 0.02	0.0000	DL 0.02	0.0000	DL 0.02	0.0000
DOC	53.000	58.000	1.094	NA	0.0000	27.000	0.5094	17.000	0.3208
F	0.700	0.600	0.857	0.800	1.1429	0.600	0.8571	0.800	1.1429
Fe	0.140	0.120	0.857	0.090	0.6429	0.090	0.6429	0.130	0.9286
Hg	DL 0.000002	0.0002	ERR	DL 0.0002	ERR	DL 0.0002	ERR	DL 0.0002	ERR
K	17.500	8.200	0.469	12.000	0.6857	14.800	0.8457	10.700	0.6114
Mg	60.600	87.500	1.444	104.000	1.7162	102.000	1.6832	130.000	2.1452
Mn	4.560	1.230	0.270	1.770	0.3882	2.980	0.6558	1.310	0.2873
Mo	1.820	1.620	0.890	1.620	0.8901	1.700	0.9341	1.700	0.9341
Na	225.000	231.000	1.027	230.000	1.0222	240.000	1.0667	242.000	1.0756
N	0.060	DL 0.04	0.000	DL 0.04	0.0000	DL 0.04	0.0000	DL 0.04	0.0000
NO3	DL 0.1	DL 0.1	ERR	DL 0.1	ERR	DL 0.1	ERR	DL 0.1	ERR
Pb	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
pH	7.000	7.500	1.071	7.390	1.0557	7.370	1.0529	7.430	1.0614
PO4	3.300	1.400	0.424	0.600	0.1818	1.000	0.3030	1.500	0.4545
Ra226	13.000	0.500	0.0385	0.500	0.0385	0.500	0.0385	0.800	0.0615
Ra228	1.100	NA	0.000	NA	0.0000	NA	0.0000	NA	0.0000
Sb	DL 0.003	0.004	ERR	DL 0.003	ERR	0.004	ERR	DL 0.003	ERR
Se	0.071	0.037	0.521	0.044	0.6197	0.043	0.6056	0.034	0.4789
SiO2	53.000	39.000	0.736	40.000	0.7547	46.000	0.8679	46.000	0.8679
Sr	0.015	0.012	0.800	0.013	0.8667	0.013	0.8667	0.011	0.7333
SO4	1750.000	1690.000	0.966	1740.000	0.9943	1700.000	0.9714	1740.000	0.9943
Sr	2.680	2.330	0.869	2.420	0.9030	2.570	0.9590	2.760	1.0299
TDS	3200.000	3070.000	0.959	3070.000	0.9594	3050.000	0.9531	3140.000	0.9813
Tl	DL 0.01	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR	DL 0.01	ERR
U	3.600	3.170	0.880	3.910	1.0861	3.160	0.8778	3.270	0.9083
V	13.700	4.480	0.327	2.830	0.2066	5.350	0.3905	3.070	0.2241
Zn	1.330	0.167	0.126	1.360	1.0226	1.450	1.0902	0.203	0.1541

NA: NOT ANALYZED

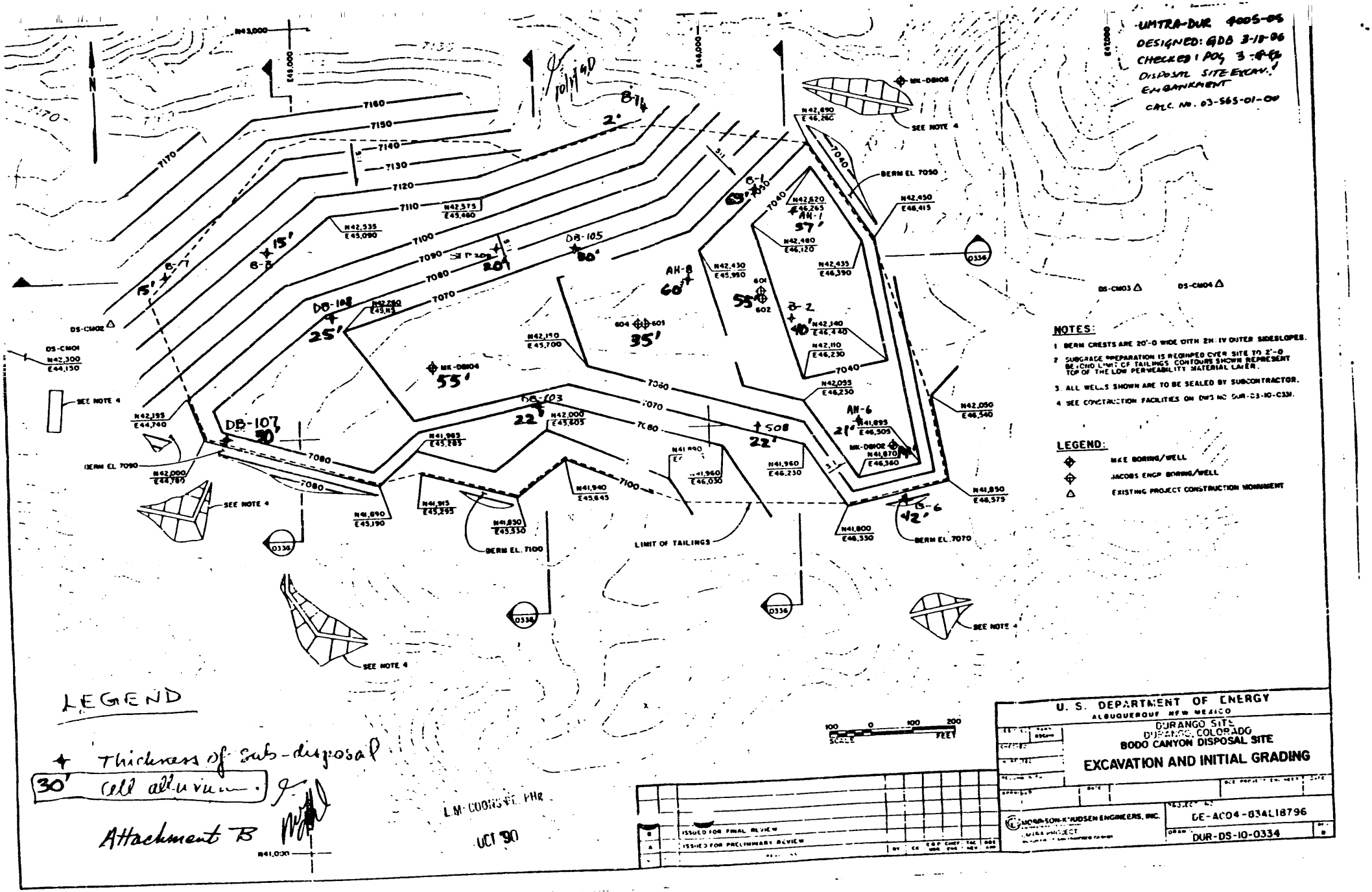
9/26/90

10/1/90

L.M. CO... HF

'90

UMTRA-DUR 4005-06
DESIGNED: GDB 3-18-96
CHECKED: POY 3-18-96
DISPOSAL SITE EXCAV./EMBANKMENT
CALC. NO. 03-S65-01-00



LEGEND

✦ Thickness of sub-disposal

30' cell alluvium

Attachment B

7/31/91
ET

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

30
24

CALC NO. DUR03-02-91-14-11-00 DISCIPLINE HYDRO NO. OF SHEETS 26

PROJECT:
UMTRA

SITE:
DURANGO DISPOSAL SITE

FEATURE:
STATISTICAL ANALYSIS OF EXISTING ALLUVIAL GROUNDWATER QUALITY AT THE DURANGO DISPOSAL SITE.

SOURCES OF DATA:
UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:
US EPA (1989) Statistical Analysis of Groundwater Monitoring Data @ RCRA Facilities

PRELIMINARY CALC. ☒ FINAL CALC. ☐ SUPERSEDES CALC. NO. _____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
00		Clark Rowe	2/19/91	Klingenberg	12 Feb 91	KB	02/21/91
01	Updated data tables + revised	C		TOD MONKS	7/31/91	1	
	text	Clark Rowe	7/24/91	TOD MONKS	8/13/91		
02	added table [illegible]	Clark Rowe	8/10/91			KB	08/15/91

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7/24/91
7/31/91
ETW

DURANGO CALCULATION DUR03-02-91-14-11-00

STATISTICAL ANALYSIS OF EXISTING ALLUVIAL GROUNDWATER QUALITY

AT THE DURANGO DISPOSAL SITE

PURPOSE

This calculation is divided into two parts. Part One addresses groundwater quality for those constituents which have EPA Maximum Concentration Limits (MCLs). Part Two determines if there is statistical evidence of alluvial groundwater contamination at the Durango disposal site for those hazardous constituents that do not have MCLs.

PART ONE

PROCEDURES

A statistical analysis of alluvial groundwater quality from September 1987 to October 1990 is presented in Table 1. To confirm whether the presence of these hazardous constituents represents alluvial groundwater contamination in areas monitored by specific wells, the maximum observed concentrations and lower end of the 98 percent confidence interval for these constituents in the alluvial groundwater for each monitor well were compared with the MCLs (.

According to "Statistical analyses of ground-water monitoring data at RCRA facilities - interim final guidance" (EPA, 1989), if the lower end of the confidence interval exceeds the MCLs, there is statistical evidence of an exceedence of the MCLs.

ASSUMPTIONS

It is assumed that the groundwater samples collected from the alluvial monitor wells adequately represent existing alluvial groundwater quality.

DATA SOURCES

The monitor well concentration data were obtained from the UMTRA DART data management system.

CONCLUSIONS

Hazardous constituents with MCLs that exceeded the laboratory method detection limits in groundwater from alluvial monitor wells at the disposal site are listed in Table 1. These include arsenic, barium, cadmium, chromium, lead, mercury, molybdenum, net gross alpha, nitrate, radium-226 and -228, selenium, silver, and uranium. All of these constituents exceed laboratory method detection limits in the tailings pore water. Therefore, the presence of these hazardous constituents in groundwater is possibly related to

TABLE 1.

GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY				MG/L CACO3								
0606	8	348.0000	581.0000	389.5000	422.1250	79.4453	0.1882	0.0	337.9167	506.3333	NORMAL	
0608	13	310.0000	461.0000	387.0000	387.6154	38.4177	0.0991	0.0	359.0489	416.1819	NORMAL	
0614	6	324.0000	401.0000	398.5000	384.8333	30.2352	0.0786	0.0	343.2976	426.3691	NORMAL	
0615	3	420.0000	959.0000	715.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	418.0000	432.0000	423.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	426.0000	426.0000	426.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ALUMINUM				MG/L								
0606	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0614	2	0.0250	0.0500	0.0375	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	2	0.0250	0.0500	0.0375	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM				MG/L								
0606	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0614	2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ANTIMONY				MG/L								
0606	4	0.0015	0.0015	0.0015	NA	NA	NA	100.0	0.0015	0.0015	NONPARAMETRIC	2,4
0608	6	0.0015	0.0015	0.0015	NA	NA	NA	100.0	0.0015	0.0015	NONPARAMETRIC	2,6
0614	6	0.0015	0.0100	0.0015	NA	NA	NA	100.0	0.0015	0.0100	NONPARAMETRIC	2,6
0615	3	0.0015	0.0050	0.0020	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	0.0015	0.0100	0.0015	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0100	0.0100	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ARSENIC				MG/L								
0606	10	0.0050	0.0200	0.0050	NA	NA	NA	70.0	0.0050	0.0070	NONPARAMETRIC	2
0608	13	0.0040	0.0100	0.0050	NA	NA	NA	84.6	0.0050	0.0050	NONPARAMETRIC	2

STAT. MAX. BG = 0.01 NOT EXCEEDED

STAT. MAX.

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ARSENIC				MG/L								
0614	6	0.0050	0.0150	0.0050	NA	NA	NA	100.0	0.0050	0.0150	NONPARAMETRIC	2,6
0615	3	0.0010	0.0050	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0150	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0150	0.0150	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
BARIUM				MG/L								
0606	8	0.0200	0.0500	0.0500	NA	NA	NA	75.0	0.0200	0.0500	NONPARAMETRIC	2
0608	11	0.0500	0.0600	0.0500	NA	NA	NA	63.6	0.0500	0.0500	NONPARAMETRIC	2
0614	5	0.0400	0.0500	0.0500	NA	NA	NA	80.0	0.0400	0.0500	NONPARAMETRIC	2,5
0615	3	0.0300	0.0500	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	2	0.0200	0.0500	0.0350	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0620	1	0.0200	0.0200	0.0200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
BERYLLIUM				MG/L								
0606	5	0.0025	0.0050	0.0050	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,5
0608	8	0.0025	0.0050	0.0050	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2
0614	6	0.0025	0.0050	0.0050	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,6
0615	3	0.0025	0.0050	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0025	0.0050	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CADMIUM				MG/L								
0606	10	0.0005	0.0080	0.0005	NA	NA	NA	80.0	0.0005	0.0030	NONPARAMETRIC	2
0608	13	0.0005	0.0070	0.0005	NA	NA	NA	76.9	0.0005	0.0030	NONPARAMETRIC	2
0614	6	0.0005	0.0005	0.0005	NA	NA	NA	100.0	0.0005	0.0005	NONPARAMETRIC	2,6
0615	3	0.0003	0.0010	0.0005	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	0.0005	0.0005	0.0005	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0005	0.0005	0.0005	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CALCIUM				MG/L								
0606	10	0.0400	432.0000	316.5000	274.5040	148.6878	0.5417	0.0	141.8628	407.1452	NORMAL	
0608	13	122.0000	251.0000	217.0000	214.6923	34.9413	0.1628	0.0	188.7108	240.6738	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CALCIUM				MG/L								
0614	6	217.0000	294.0000	283.0000	274.8333	29.0889	0.1058	0.0	234.8722	314.7964	NORMAL	
0615	3	85.0000	178.0000	132.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	260.0000	280.0000	278.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	280.0000	280.0000	280.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHEMICAL OXYGEN DEMAND				MG/L								
0606	1	12.0000	12.0000	12.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	1	8.0000	8.0000	8.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHLORIDE				MG/L								
0606	10	0.5000	29.8000	10.4000	11.1200	7.3168	0.6580	10.0	4.5929	17.6471	NORMAL	
0608	13	14.0000	44.0000	31.0000	31.1692	7.6239	0.2446	0.0	25.5003	36.8382	NORMAL	
0614	6	29.0000	43.0000	38.8500	38.1167	4.9882	0.1309	0.0	31.2642	44.9692	NORMAL	
0615	3	31.5000	43.0000	39.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	40.0000	45.0000	40.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	44.8000	44.8000	44.8000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
CHROMIUM				MG/L								
0606	8	0.0050	0.1300	0.0050	NA	NA	NA	62.5	0.0050	0.1300	NONPARAMETRIC	2
0608	11	0.0050	0.0900	0.0050	NA	NA	NA	81.8	0.0050	0.0800	NONPARAMETRIC	2
0614	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
0615	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
COBALT				MG/L								
0606	5	0.0200	0.0250	0.0250	NA	NA	NA	80.0	0.0200	0.0250	NONPARAMETRIC	2,5
0608	7	0.0100	0.0250	0.0250	NA	NA	NA	85.7	0.0100	0.0250	NONPARAMETRIC	2
0614	6	0.0150	0.0250	0.0250	NA	NA	NA	100.0	0.0150	0.0250	NONPARAMETRIC	2,6
0615	3	0.0200	0.0250	0.0250	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	0.0150	0.0250	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0150	0.0150	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

STAT. MAX.
B.G. = 0.025

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
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09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
COPPER				MG/L								
0606	8	0.0100	0.0200	0.0100	NA	NA	NA	87.5	0.0100	0.0200	NONPARAMETRIC	2
0608	11	0.0100	0.0200	0.0100	NA	NA	NA	90.9	0.0100	0.0100	NONPARAMETRIC	2
0614	6	0.0050	0.0100	0.0100	NA	NA	NA	100.0	0.0050	0.0100	NONPARAMETRIC	2,6
0615	3	0.0100	0.0100	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0100	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CYANIDE				MG/L								
0606	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0608	5	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,5
0614	4	0.0050	0.0100	0.0050	NA	NA	NA	100.0	0.0050	0.0100	NONPARAMETRIC	2,4
0615	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0300	0.0100	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE				MG/L								
0606	8	0.0500	0.5000	0.4000	0.3812	0.1414	0.3708	12.5	0.2314	0.5311	NORMAL	
0608	11	0.3000	0.4000	0.3700	0.3509	0.0495	0.1410	0.0	0.3097	0.3922	NORMAL	
0614	6	0.2000	0.3000	0.2500	0.2500	0.0548	0.2191	0.0	0.1748	0.3252	NORMAL	
0615	3	0.4000	0.6000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.3000	0.4000	0.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.4000	0.4000	0.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS ALPHA				PCI/L								
0606	8	0.1000	69.0000	5.1000	NA	NA	NA	37.5	0.1000	69.0000	NONPARAMETRIC	2
0608	10	0.5000	19.0000	3.2000	NA	NA	NA	20.0	0.5000	10.0000	NONPARAMETRIC	2
0614	5	0.5000	38.2000	11.0000	NA	NA	NA	20.0	0.5000	38.2000	NONPARAMETRIC	2,5
0615	3	0.5000	46.0000	29.3000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	2	1.9000	10.9000	6.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
GROSS BETA				PCI/L								
0606	8	0.9000	32.0000	15.0000	14.4250	9.6821	0.6712	0.0	4.1625	24.6875	NORMAL	

STAT. MAX.
B.G.: 0.01

STAT. MAX.
B.G.: 0.574

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
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2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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EM

GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
GROSS BETA				PCI/L								
0608	11	0.2500	20.5000	7.8000	8.8227	5.9990	0.6799	9.1	3.8233	13.8221	NORMAL	
0614	6	0.2500	11.0000	8.9000	NA	NA	NA	16.7	0.2500	11.0000	NONPARAMETRIC	2,6
0615	3	24.2000	40.4000	27.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.2500	14.3000	9.5000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	4.0000	4.0000	4.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
IRON				MG/L								
0606	10	0.0150	2.4700	0.1000	NA	NA	NA	30.0	0.0150	1.6800	NONPARAMETRIC	2
0608	13	0.0150	0.0700	0.0500	NA	NA	NA	38.5	0.0150	0.0700	NONPARAMETRIC	2
0614	6	0.0150	0.2000	0.0600	NA	NA	NA	16.7	0.0150	0.2000	NONPARAMETRIC	2,6
0615	3	0.0150	0.0400	0.0150	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	0.0150	0.0800	0.0300	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	0.0150	0.0150	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
LEAD				MG/L								
0606	8	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2
0608	11	0.0050	0.0600	0.0050	NA	NA	NA	81.8	0.0050	0.0100	NONPARAMETRIC	2
0614	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
0615	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MAGNESIUM				MG/L								
0606	10	0.0400	225.0000	177.5000	149.7040	71.5838	0.4782	0.0	85.8457	213.5623	NORMAL	
0608	13	109.0000	158.0000	140.0000	138.8462	13.3657	0.0963	0.0	128.9078	148.7845	NORMAL	
0614	6	104.0000	144.0000	129.5000	127.5000	13.5757	0.1065	0.0	108.8503	146.1497	NORMAL	
0615	3	53.0000	102.0000	81.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	139.0000	152.0000	145.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	173.0000	173.0000	173.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
MANGANESE				MG/L								
0606	10	0.0050	2.9800	1.1450	1.1505	0.9298	0.8081	10.0	0.3211	1.9799	NORMAL	
0608	13	0.0050	0.0600	0.0200	NA	NA	NA	38.5	0.0050	0.0500	NONPARAMETRIC	2

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
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2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
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SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE				MG/L								
0614	6	0.0050	0.1500	0.0200	NA	NA	NA	16.7	0.0050	0.1500	NONPARAMETRIC	2,6
0615	3	0.1100	0.2900	0.1700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MERCURY				MG/L								
0606	10	0.0001	0.0004	0.0001	NA	NA	NA	90.0	0.0001	0.0001	NONPARAMETRIC	2
0608	13	0.0001	0.0005	0.0001	NA	NA	NA	92.3	0.0001	0.0001	NONPARAMETRIC	2
0614	5	0.0001	0.0002	0.0001	NA	NA	NA	80.0	0.0001	0.0002	NONPARAMETRIC	2,5
0615	3	0.0001	0.0001	0.0001	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0001	0.0001	0.0001	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0001	0.0001	0.0001	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
MOLYBDENUM				MG/L								
0606	10	0.0040	0.2000	0.0050	NA	NA	NA	50.0	0.0050	0.0800	NONPARAMETRIC	2
0608	13	0.0020	0.1000	0.0200	NA	NA	NA	38.5	0.0050	0.0900	NONPARAMETRIC	2
0614	6	0.0050	0.0300	0.0050	NA	NA	NA	83.3	0.0050	0.0300	NONPARAMETRIC	2,6
0615	3	0.0500	0.1020	0.0900	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0300	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NET GROSS ALPHA ***				PCI/L								
0606	8	-5.3900	63.7200	3.2500	NA	NA	NA	0.0	-5.3900	63.7200	NONPARAMETRIC	9
0608	10	-2.9300	16.1900	0.4550	NA	NA	NA	0.0	-0.5300	7.7400	NONPARAMETRIC	9
0614	5	-3.1400	37.8600	8.2600	NA	NA	NA	0.0	-3.1400	37.8600	NONPARAMETRIC	9,5
0615	3	-59.1800	30.9100	5.9800	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	2	-0.1600	10.2100	5.0250	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	-1.5600	-1.5600	-1.5600	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NICKEL				MG/L								
0606	5	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,5

STAT. MAX.
B.G. = 0.02

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
* The statistical maximum is the 99 percent one sided confidence interval, α = 0.01
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

STAT. MAX. B.G. NOT EXCEEDED

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NICKEL				MG/L								
0608	7	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2
0614	6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6
0615	3	0.0200	0.0200	0.0200	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	0.0200	0.0200	0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0200	0.0200	0.0200	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
NITRATE				MG/L								
0606	8	0.1000	6.1000	0.5000	NA	NA	NA	50.0	0.1000	6.1000	NONPARAMETRIC	2
0608	11	1.2000	6.9000	3.0000	3.6273	1.9365	0.5339	0.0	2.0134	5.2611	NORMAL	
0614	6	0.5000	10.0000	4.1500	NA	NA	NA	16.7	0.5000	10.0000	NONPARAMETRIC	2,6
0615	3	0.5000	11.2000	5.2000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	2.0000	5.8000	5.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	3.1000	3.1000	3.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NITRITE AND NITRATE				MG/L								
0614	2	0.5000	1.6800	1.0900	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0618	1	1.3200	1.3200	1.3200	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.7500	0.7500	0.7500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
POTASSIUM				MG/L								
0606	10	0.1300	10.3000	5.2600	5.7260	3.0171	0.5269	0.0	3.0345	8.4175	NORMAL	
0608	13	2.3000	5.0200	2.8900	3.0569	0.6734	0.2203	0.0	2.5562	3.5576	NORMAL	
0614	6	1.4000	1.9400	1.7950	1.7550	0.2028	0.1155	0.0	1.4765	2.0335	NORMAL	
0615	3	8.2000	18.0000	14.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	2.1000	2.5000	2.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	2.2000	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226				PCI/L								
0606	8	0.1000	0.7720	0.1000	0.1408	2.0732	NA	0.0	0.0650	0.3049	LOGNORMAL	7,8
0608	13	0.1000	1.3300	0.1000	0.1696	2.1378	NA	0.0	0.0964	0.2983	LOGNORMAL	7,8
0614	6	0.0500	1.9000	0.0500	NA	NA	NA	83.3	0.0500	1.9000	NONPARAMETRIC	2,6

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-226				PCI/L								
0615	2	0.7380	1.2000	0.9690	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.0500	0.2000	0.1000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	0.1000	0.1000	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-226 + RADIUM-228				PCI/L								
0606	8	0.2000	1.4000	0.7500	0.8337	0.3985	0.4780	0.0	0.4113	1.2562	NORMAL	
0608	13	0.2000	1.8300	0.7000	0.7715	0.4500	0.5833	0.0	0.4369	1.1062	NORMAL	
0614	6	0.5500	6.9500	0.9000	1.2724	2.7166	NA	0.0	0.3224	5.0221	LOGNORMAL	7,8
0615	2	1.2400	4.1000	2.6700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.5500	9.4000	1.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1.8000	1.8000	1.8000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
RADIUM-228				PCI/L								
0606	8	0.1000	1.3000	0.5000	NA	NA	NA	37.5	0.1000	1.3000	NONPARAMETRIC	2
0608	13	0.1000	1.2000	0.5000	NA	NA	NA	46.2	0.1000	0.9000	NONPARAMETRIC	2
0614	6	0.5000	6.9000	0.7000	NA	NA	NA	16.7	0.5000	6.9000	NONPARAMETRIC	2,6
0615	2	0.5000	2.9000	1.7000	NA	NA	NA	50.0	NA	NA	UNKNOWN	1
0618	3	0.5000	9.3000	1.1000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0620	1	1.7000	1.7000	1.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
REDOX POTENTIAL				MVOLTS								
0608	1	431.0000	431.0000	431.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0614	1	368.3000	368.3000	368.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	371.9000	371.9000	371.9000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	381.7000	381.7000	381.7000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM				MG/L								
0606	10	0.0005	0.0240	0.0043	NA	NA	NA	50.0	0.0010	0.0120	NONPARAMETRIC	2
0608	13	0.0010	0.0230	0.0140	NA	NA	NA	23.1	0.0025	0.0200	NONPARAMETRIC	2
0614	6	0.0025	0.0190	0.0090	NA	NA	NA	66.7	0.0025	0.0190	NONPARAMETRIC	2,6
0615	3	0.0050	0.0200	0.0070	NA	NA	NA	33.3	NA	NA	UNKNOWN	1

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SELENIUM				MG/L								
0618	3	0.0070	0.0150	0.0150	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	0.0150	0.0150	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SILVER				MG/L								
0606	10	0.0050	0.0200	0.0050	NA	NA	NA	70.0	0.0050	0.0200	NONPARAMETRIC	2
0608	13	0.0050	0.0200	0.0050	NA	NA	NA	84.6	0.0050	0.0100	NONPARAMETRIC	2
0614	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
0615	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
SODIUM				MG/L								
0606	10	0.1000	480.0000	29.4500	27.1325	9.2367	NA	0.0	3.7340	197.1535	LOGNORMAL	7,8
0608	13	54.5000	108.0000	75.9000	81.8769	15.9663	0.1950	0.0	70.0048	93.7491	NORMAL	
0614	6	58.7000	83.5000	81.8500	78.0667	9.6475	0.1236	0.0	64.8133	91.3200	NORMAL	
0615	3	361.0000	510.0000	443.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	114.0000	117.0000	117.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	130.0000	130.0000	130.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SPECIFIC CONDUCTANCE				UMHO/CM								
0606	11	290.0000	1900.0000	1200.0000	1257.6364	458.9214	0.3649	0.0	875.1817	1640.0911	NORMAL	
0608	14	100.0000	2330.0000	1200.0000	1253.2143	509.2514	0.4064	0.0	892.5409	1613.8876	NORMAL	
0614	6	1190.0000	2460.0000	1485.0000	1590.0000	442.8092	0.2785	0.0	981.6884	2198.3116	NORMAL	
0615	4	360.0000	1700.0000	1020.0000	1025.0000	609.8360	0.5950	0.0	-359.6327	2409.6327	NORMAL	
0618	3	1500.0000	1600.0000	1590.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1700.0000	1700.0000	1700.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
STRONTIUM				MG/L								
0608	1	1.4000	1.4000	1.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0614	1	0.9000	0.9000	0.9000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	1.3000	1.3000	1.3000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

MAX. OBS.
3 [illegible] 2.2

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SULFATE				MG/L								
0606	10	0.0500	1760.0000	1147.0000	1071.4050	495.3765	0.4624	10.0	629.4902	1513.3198	NORMAL	
0608	13	524.0000	1010.0000	850.0000	847.4615	130.5160	0.1540	0.0	750.4130	944.5101	NORMAL	
0614	6	737.0000	1042.0000	987.5000	953.6667	110.9318	0.1163	0.0	801.2735	1106.0598	NORMAL	
0615	3	720.0000	1220.0000	1120.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	948.0000	1020.0000	1020.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	1090.0000	1090.0000	1090.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFIDE				MG/L								
0606	5	0.0500	0.0800	0.0500	NA	NA	NA	80.0	0.0500	0.0800	NONPARAMETRIC	2,5
0608	6	0.0500	0.0500	0.0500	NA	NA	NA	100.0	0.0500	0.0500	NONPARAMETRIC	2,6
0614	5	0.0500	119.0000	0.0500	NA	NA	NA	60.0	0.0500	119.0000	NONPARAMETRIC	2,5
0615	3	0.0200	7.6000	0.0500	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TEMPERATURE				C - DEGREE								
0606	11	7.0000	11.0000	9.0000	9.1091	1.0329	0.1134	0.0	8.2483	9.9699	NORMAL	
0608	14	8.7000	11.0000	9.2500	9.5071	0.6754	0.0710	0.0	9.0288	9.9855	NORMAL	
0614	6	9.0000	12.0000	10.7000	10.6000	1.0334	0.0975	0.0	9.1803	12.0197	NORMAL	
0615	4	6.0000	14.0000	10.5000	10.2500	3.3040	0.3223	0.0	2.7482	17.7518	NORMAL	
0618	3	10.0000	11.1000	11.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	11.0000	11.0000	11.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
THALLIUM				MG/L								
0606	5	0.0005	0.0500	0.0050	NA	NA	NA	100.0	0.0005	0.0500	NONPARAMETRIC	2,5
0608	8	0.0005	0.0500	0.0050	NA	NA	NA	100.0	0.0005	0.0500	NONPARAMETRIC	2
0614	6	0.0050	0.0150	0.0050	NA	NA	NA	100.0	0.0050	0.0150	NONPARAMETRIC	2,6
0615	3	0.0005	0.0500	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0150	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0150	0.0150	0.0150	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
THORIUM-230				PCI/L								
0606	1	0.1000	0.1000	0.1000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

STAT. MAX. B.G. = 8

STAT. MAX. B.G. = 0.05

* The statistical maximum is the 99 percent one sided confidence interval, α = 0.01
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
THORIUM-230				PCI/L								
0608	2	0.2000	0.3000	0.2500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TIN				MG/L								
0606	5	0.0025	0.0025	0.0025	NA	NA	NA	100.0	0.0025	0.0025	NONPARAMETRIC	2,5
0608	7	0.0025	0.0025	0.0025	NA	NA	NA	100.0	0.0025	0.0025	NONPARAMETRIC	2
0614	6	0.0025	0.0250	0.0025	NA	NA	NA	100.0	0.0025	0.0250	NONPARAMETRIC	2,6
0615	3	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0618	3	0.0025	0.0250	0.0125	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
0620	1	0.0250	0.0250	0.0250	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
TOTAL DISSOLVED SOLIDS				MG/L								
0606	10	5.0000	2850.0000	2056.0000	1914.7000	791.5237	0.4134	10.0	1208.5987	2620.8013	NORMAL	
0608	13	1270.0000	1810.0000	1610.0000	1609.8462	156.6535	0.0973	0.0	1493.3625	1726.3299	NORMAL	
0614	5	1350.0000	3760.0000	1910.0000	2128.0000	940.5424	0.4420	0.0	551.9243	3704.0757	NORMAL	
0615	3	1750.0000	2108.0000	1880.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	1840.0000	1970.0000	1960.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	2090.0000	2090.0000	2090.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON				MG/L								
0606	1	27.0000	27.0000	27.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0608	3	3.0000	39.3000	6.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0614	1	16.0000	16.0000	16.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0615	1	31.0000	31.0000	31.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	1	9.0000	9.0000	9.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM				MG/L								
0606	10	0.0001	0.0140	0.0070	NA	NA	NA	20.0	0.0015	0.0103	NONPARAMETRIC	2
0608	13	0.0009	0.0053	0.0030	NA	NA	NA	15.4	0.0015	0.0050	NONPARAMETRIC	2
0614	6	0.0005	0.0053	0.0035	NA	NA	NA	16.7	0.0005	0.0053	NONPARAMETRIC	2,6
0615	3	0.0220	0.0870	0.0340	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0618	3	0.0010	0.0046	0.0030	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
0620	1	0.0030	0.0030	0.0030	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY LOCATION
DOWNGRADIENT ALLUVIUM MONITOR WELLS: 606, 608, 614, 615, 618, AND 620
SITE: DUR03 BODO CANYON
09/13/87 TO 04/23/91
REPORT DATE: 07/23/91

PARAMETER NAME				UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
LOC.	SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM				MG/L								
0606	5	0.0050	0.0500	0.0050	NA	NA	NA	60.0	0.0050	0.0500	NONPARAMETRIC	2,5
0608	7	0.0050	0.0400	0.0200	NA	NA	NA	42.9	0.0050	0.0400	NONPARAMETRIC	2
0614	5	0.0050	0.0200	0.0050	NA	NA	NA	60.0	0.0050	0.0200	NONPARAMETRIC	2,5
0615	3	0.0050	0.0100	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0618	3	0.0050	0.0200	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ZINC				MG/L								
0606	8	0.0025	0.0300	0.0115	NA	NA	NA	25.0	0.0025	0.0300	NONPARAMETRIC	2
0608	11	0.0025	0.0120	0.0025	NA	NA	NA	54.5	0.0025	0.0110	NONPARAMETRIC	2
0614	6	0.0025	0.0110	0.0025	NA	NA	NA	66.7	0.0025	0.0110	NONPARAMETRIC	2,6
0615	3	0.0025	0.0200	0.0060	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
0618	3	0.0025	0.0070	0.0050	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
0620	1	0.0025	0.0025	0.0025	NA	NA	NA	100.0	NA	NA	UNKNOWN	1

STAT. MAX.
B.G. = 0.02

STAT. MAX.
B.G. = 0.01

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
5) The stat. range is the 93.8% confidence interval due to a sample size of 5. The maximum is the 96.9% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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TABLE 1. CONTINUED

GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	10	338.0000	2892.0000	471.0000	555.6380	1.8155	NA	0.0	326.4031	945.8660	LOGNORMAL	7,8
ALUMINUM	MG/L	2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
ALUMINUM (TOTAL)	MG/L	1	2.1500	2.1500	2.1500	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	1	0.5000	0.5000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
AMMONIUM (TOTAL)	MG/L	1	0.2000	0.2000	0.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY	MG/L	6	0.0015	0.0100	0.0015	NA	NA	NA	83.3	0.0015	0.0100	NONPARAMETRIC	2,6
ANTIMONY (TOTAL)	MG/L	4	0.0015	0.0130	0.0033	NA	NA	NA	75.0	0.0015	0.0130	NONPARAMETRIC	2,4
ARSENIC	MG/L	6	0.0020	0.0150	0.0050	NA	NA	NA	83.3	0.0020	0.0150	NONPARAMETRIC	2,6
ARSENIC (TOTAL)	MG/L	4	0.0050	0.0100	0.0050	NA	NA	NA	75.0	0.0050	0.0100	NONPARAMETRIC	2,4

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
BARIUM	MG/L	6	0.0300	0.1400	0.0500	NA	NA	NA	50.0	0.0300	0.1400	NONPARAMETRIC	2,6
BARIUM (TOTAL)	MG/L	3	0.0500	0.5100	0.5000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
BERYLLIUM	MG/L	6	0.0025	0.0050	0.0025	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,6
BERYLLIUM (TOTAL)	MG/L	4	0.0025	0.0050	0.0037	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,4
CADMIUM	MG/L	6	0.0002	0.0005	0.0005	NA	NA	NA	83.3	0.0002	0.0005	NONPARAMETRIC	2,6
CADMIUM (TOTAL)	MG/L	4	0.0005	0.0140	0.0005	NA	NA	NA	75.0	0.0005	0.0140	NONPARAMETRIC	2,4
CALCIUM	MG/L	6	226.0000	284.0000	249.5000	253.0000	19.7585	0.0781	0.0	225.8566	280.1434	NORMAL	
CALCIUM (TOTAL)	MG/L	4	230.0000	257.0000	246.0000	244.7500	12.8938	0.0527	0.0	215.4746	274.0254	NORMAL	
CHLORIDE	MG/L	6	14.0000	40.5000	38.0000	34.4167	10.2099	0.2967	0.0	20.3908	48.4425	NORMAL	
CHLORIDE (TOTAL)	MG/L	3	38.0000	42.0000	42.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
CHROMIUM (TOTAL)	MG/L	4	0.0050	0.0100	0.0050	NA	NA	NA	75.0	0.0050	0.0100	NONPARAMETRIC	2,4
COBALT	MG/L	6	0.0100	0.0250	0.0250	NA	NA	NA	83.3	0.0100	0.0250	NONPARAMETRIC	2,6
COBALT (TOTAL)	MG/L	4	0.0150	0.0250	0.0250	NA	NA	NA	100.0	0.0150	0.0250	NONPARAMETRIC	2,4
COPPER	MG/L	6	0.0050	0.0100	0.0100	NA	NA	NA	83.3	0.0050	0.0100	NONPARAMETRIC	2,6
COPPER (TOTAL)	MG/L	4	0.0100	0.0500	0.0400	NA	NA	NA	25.0	0.0100	0.0500	NONPARAMETRIC	2,4
CYANIDE	MG/L	3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
CYANIDE (TOTAL)	MG/L	1	0.0100	0.0100	0.0100	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE	MG/L	6	0.2000	0.5000	0.4500	0.4000	0.1265	0.3162	0.0	0.2262	0.5738	NORMAL	
FLUORIDE (TOTAL)	MG/L	3	0.3000	0.4000	0.4000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1

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1) A minimum of 4 samples must be available for the statistical analysis.
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4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one s[illegible] confidence int.
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
GROSS ALPHA			PCI/L								
4	0.5000	23.8000	1.5000	NA	NA	NA	50.0	0.5000	23.8000	NONPARAMETRIC	2,4
GROSS ALPHA (TOTAL)			PCI/L								
3	15.3000	3000.0000	20.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
GROSS BETA			PCI/L								
6	8.0000	33.8000	10.0500	15.0167	10.0921	0.6721	0.0	1.1526	28.8807	NORMAL	
GROSS BETA (TOTAL)			PCI/L								
3	26.7000	43.0000	39.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
IRON			MG/L								
6	0.0150	0.9000	0.2600	NA	NA	NA	33.3	0.0150	0.9000	NONPARAMETRIC	2,6
IRON (TOTAL)			MG/L								
4	14.0000	53.0000	31.7000	32.6000	20.9883	0.6438	0.0	-15.0538	80.2538	NORMAL	
LEAD			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
LEAD (TOTAL)			MG/L								
4	0.0050	0.0350	0.0075	NA	NA	NA	25.0	0.0050	0.0350	NONPARAMETRIC	2,4
MAGNESIUM			MG/L								
6	195.0000	227.0000	214.0000	212.8333	12.4486	0.0585	0.0	195.7321	229.9346	NORMAL	
MAGNESIUM (TOTAL)			MG/L								
4	206.0000	210.0000	208.0000	208.0000	1.6330	0.0079	0.0	204.2923	211.7077	NORMAL	

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4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE	MG/L	6	0.3900	0.9800	0.6550	0.6400	0.2096	0.3275	0.0	0.3521	0.9279	NORMAL	
MANGANESE (TOTAL)	MG/L	4	0.7200	1.2100	1.0100	0.9875	0.2545	0.2577	0.0	0.4097	1.5653	NORMAL	
MERCURY	MG/L	6	0.0001	0.0001	0.0001	NA	NA	NA	100.0	0.0001	0.0001	NONPARAMETRIC	2,6
MERCURY (TOTAL)	MG/L	4	0.0001	0.0001	0.0001	NA	NA	NA	100.0	0.0001	0.0001	NONPARAMETRIC	2,4
MOLYBDENUM	MG/L	6	0.0050	0.2000	0.0230	NA	NA	NA	33.3	0.0050	0.2000	NONPARAMETRIC	2,6
MOLYBDENUM (TOTAL)	MG/L	4	0.0050	0.0250	0.0050	NA	NA	NA	100.0	0.0050	0.0250	NONPARAMETRIC	2,4
NET GROSS ALPHA ***	PCI/L	4	-0.5300	22.4300	0.4700	NA	NA	NA	0.0	-0.5300	22.4300	NONPARAMETRIC	9,4
NET GROSS ALPHA (TOTAL) ****	PCI/L	2	14.9600	18.9000	16.9300	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NICKEL	MG/L	6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
**** NET GROSS ALPHA (TOTAL) (TOTAL GROSS ALPHA - TOTAL URANIUM)
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
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9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
NICKEL (TOTAL)	MG/L	4	0.0200	0.0400	0.0200	NA	NA	NA	75.0	0.0200	0.0400	NONPARAMETRIC	2,4
NITRATE	MG/L	6	0.4000	2.2000	0.5000	NA	NA	NA	50.0	0.4000	2.2000	NONPARAMETRIC	2,6
NITRATE (TOTAL)	MG/L	3	0.5000	1.3000	1.0000	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
NITRITE AND NITRATE	MG/L	1	0.4700	0.4700	0.4700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
NITRITE AND NITRATE (TOTAL)	MG/L	1	0.5000	0.5000	0.5000	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
POTASSIUM	MG/L	6	2.9000	11.0000	3.7000	4.9000	3.0874	0.6301	0.0	0.6587	9.1413	NORMAL	
POTASSIUM (TOTAL)	MG/L	4	3.9000	6.5000	5.0000	5.1000	1.2111	0.2375	0.0	2.3503	7.8497	NORMAL	
RADIUM-226	PCI/L	6	0.0500	34.9000	0.1500	NA	NA	NA	16.7	0.0500	34.9000	NONPARAMETRIC	2,6
RADIUM-226 (TOTAL)	PCI/L	4	0.6000	3.8000	0.8500	1.1076	2.3873	NA	0.0	0.1536	7.9871	LOGNORMAL	7,8

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6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
RADIUM-226 + RADIUM-228	PCI/L	6	1.0000	35.4000	1.4750	2.6551	3.8085	NA	0.0	0.4229	16.6685	LOGNORMAL	7,8
RADIUM-226 + RADIUM-228 (TOTAL)	PCI/L	4	1.6000	8.1000	4.7500	4.8000	3.5842	0.7467	0.0	-3.3380	12.9380	NORMAL	
RADIUM-228	PCI/L	6	0.5000	3.3000	1.3000	NA	NA	NA	16.7	0.5000	3.3000	NONPARAMETRIC	2,6
RADIUM-228 (TOTAL)	PCI/L	4	0.5000	7.5000	2.5500	NA	NA	NA	25.0	0.5000	7.5000	NONPARAMETRIC	2,4
REDOX POTENTIAL	MVOLTS	1	185.6000	185.6000	185.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM	MG/L	6	0.0010	0.0150	0.0025	NA	NA	NA	100.0	0.0010	0.0150	NONPARAMETRIC	2,6
SELENIUM (TOTAL)	MG/L	4	0.0010	0.0050	0.0025	NA	NA	NA	100.0	0.0010	0.0050	NONPARAMETRIC	2,4
SILVER	MG/L	6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
SILVER (TOTAL)	MG/L	4	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,4

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
SODIUM	MG/L	6	114.0000	176.0000	167.0000	159.5000	22.9151	0.1437	0.0	128.0203	190.9797	NORMAL	
SODIUM (TOTAL)	MG/L	4	160.0000	168.0000	160.5000	162.2500	3.8622	0.0238	0.0	153.4809	171.0191	NORMAL	
SPECIFIC CONDUCTANCE	UMHO/CM	10	100.0000	3040.0000	1700.0000	1656.3000	890.6647	0.5377	0.0	861.7572	2450.8428	NORMAL	
STRONTIUM	MG/L	2	2.2000	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE	MG/L	6	1299.0000	1360.0000	1330.0000	1331.5000	28.0980	0.0211	0.0	1292.9002	1370.0998	NORMAL	
SULFATE (TOTAL)	MG/L	3	1280.0000	1380.0000	1350.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFIDE	MG/L	4	0.0500	8.0000	0.4000	NA	NA	NA	25.0	0.0500	8.0000	NONPARAMETRIC	2,4
SULFIDE (TOTAL)	MG/L	3	0.0500	16.8000	0.0500	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
TEMPERATURE	C - DEGREE	10	6.0000	10.0000	9.0000	8.5500	1.3866	0.1622	0.0	7.3130	9.7870	NORMAL	
THALLIUM	MG/L	6	0.0005	0.0500	0.0100	NA	NA	NA	100.0	0.0005	0.0500	NONPARAMETRIC	2,6

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 96% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
THALLIUM (TOTAL)	MG/L	4	0.0050	0.0500	0.0050	NA	NA	NA	100.0	0.0050	0.0500	NONPARAMETRIC	2,4
TIN	MG/L	6	0.0025	0.0250	0.0085	NA	NA	NA	50.0	0.0025	0.0250	NONPARAMETRIC	2,6
TIN (TOTAL)	MG/L	4	0.0025	0.0125	0.0046	NA	NA	NA	50.0	0.0025	0.0125	NONPARAMETRIC	2,4
TOTAL DISSOLVED SOLIDS	MG/L	6	2240.0000	2440.0000	2340.0000	2349.6667	67.8872	0.0289	0.0	2256.4063	2442.9270	NORMAL	
TOTAL DISSOLVED SOLIDS (TOTAL)	MG/L	2	2370.0000	2380.0000	2375.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON	MG/L	2	10.0000	33.0000	21.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
TOTAL ORGANIC CARBON (TOTAL)	MG/L	1	36.0000	36.0000	36.0000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM	MG/L	6	0.0011	0.0020	0.0015	NA	NA	NA	50.0	0.0011	0.0020	NONPARAMETRIC	2,6
URANIUM (TOTAL)	MG/L	3	0.0005	0.0016	0.0015	NA	NA	NA	66.7	NA	NA	UNKNOWN	1
VANADIUM	MG/L	6	0.0050	0.0200	0.0075	NA	NA	NA	50.0	0.0050	0.0200	NONPARAMETRIC	2,6

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
ALLUVIUM BACKGROUND MONITOR WELL 523
SITE: DUR03 BODO CANYON
10/27/89 TO 04/25/91
REPORT DATE: 08/13/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
VANADIUM (TOTAL)			MG/L								
3	0.0250	0.0800	0.0300	NA	NA	NA	33.3	NA	NA	UNKNOWN	1
ZINC			MG/L								
6	0.0025	0.0400	0.0025	NA	NA	NA	83.3	0.0025	0.0400	NONPARAMETRIC	2,6
ZINC (TOTAL)			MG/L								
4	0.0230	0.2000	0.0925	0.1020	0.0843	0.8267	0.0	-0.0895	0.2935	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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construction water discharges from the disposal cell or discharges from the retention pond.

Maximum observed concentrations of chromium exceeded MCLs in the monitor wells 606 and 608 northeast of the disposal cell. Maximum observed concentrations of lead exceeded MCLs only in the monitor well 608. Maximum observed activities of radium-226 and -228 exceeded MCLs in the monitor wells 614 and 618 northeast of the disposal cell. Maximum concentrations of net gross alpha exceeded MCLs in monitor wells 606, 608, 614, and 618 northeast of the disposal cell and monitor well 615 east of the disposal cell. Maximum concentrations of molybdenum exceeded MCLs in monitor wells 606 and 608 northeast of the disposal cell and monitor well 615 east of the disposal cell. Maximum concentrations of selenium exceeded MCLs in monitor wells 606, 608, and 614 northeast of the disposal cell and monitor well 615 east of the disposal cell. Maximum concentrations of uranium exceeded MCLs only in monitor well 615 east of the disposal cell.

The lower end of the 98 percent confidence interval does not exceed the MCLs for any of the hazardous constituents in any monitor well, therefore there is no statistical evidence that they are groundwater contaminants that exceed the MCLs. However, the median selenium concentration in monitor well 608 exceeds the MCL.

RESULTS

There is no statistical evidence that the hazardous constituents chromium, lead, molybdenum, net gross alpha, radium-226 and -228, and uranium are groundwater contaminants in the alluvial groundwater related to seepage from the disposal cell or discharges from the holding pond. There is statistical evidence that selenium is a possible groundwater contaminant in the area of alluvial monitor well 608.

PART TWO

PROCEDURES

For hazardous constituents with no MCLs, the maximum observed concentration in downgradient groundwater was compared to the statistical maximum for background groundwater quality (DUR Calculation DUR03-02-91-14-10-00). If statistical maximums were unavailable for certain parameters due to less than four samples, comparisons were made with background observed maximums.

The criteria of exceedence of the statistical maxium was used to determine whether copper and vanadium should undergo further statistical analysis as they may be considered potential groundwater contaminants. When the proportion of nondetects in the downgradient sample population of a given constituent exceeded 50%, but at least 10% of the samples were equal to or above detection limits, a test of proportions was used. The flowchart of the

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procedure used in the statistical analysis is shown in Figure 1.

ASSUMPTIONS

It is assumed that trends of seasonality, if any, are negligible.

DATA SOURCES

The monitor well concentration data were obtained from the UMTRA DART data management system.

SOLUTION

The test of proportions was used to statistically evaluate the difference between background and downgradient well sample analyses for the hazardous constituent vanadium. For the test of proportions analyses, calculations were performed manually using the formula in the EPA document (EPA, 1989). These calculations are shown in Attachment 1.

A test of proportions could not be used to evaluate the difference between background and downgradient well sample analyses for the hazardous constituent copper. Only one sample from each monitor well where copper exceeded background (606 and 608) and from the background well (623) were above detection limits (Table 2). This is an insufficient amount of data for the test of proportions analysis.

CONCLUSIONS

Concentrations of elements included individually or as compounds that are listed as hazardous constituents in Appendix I or 40 CFR 192 and Appendix IX of 40 CFR 264 that exceeded the laboratory method detection limits include aluminum, antimony, copper, cyanide, fluoride, tin, strontium, sulfide, vanadium, and zinc (Table 1, page 2).

Aluminum is an element of a hazardous constituent compound aluminum phosphide which does not exist under normal geochemical conditions expected of uranium mill tailings. Fluoride is an element of a hardous constituent compound carbon oxyfluoride which does not exist in water. Therefore, these elements are not considered hazardous constituents at the Bodo Canyon disposal site.

Cyanide was not observed in the background groundwater, yet exceeded laboratory detection limits in monitor well 615. However, cyanide was not observed above detection limits in any tailings pore fluid samples (Durango Calculation DUR03-09-90-15-01-00). Therefore cyanide cannot be a groundwater contaminant related to disposal cell construction activities.

The statistical maximum for background groundwater quality was exceeded for the hazardous constituents copper and vanadium.

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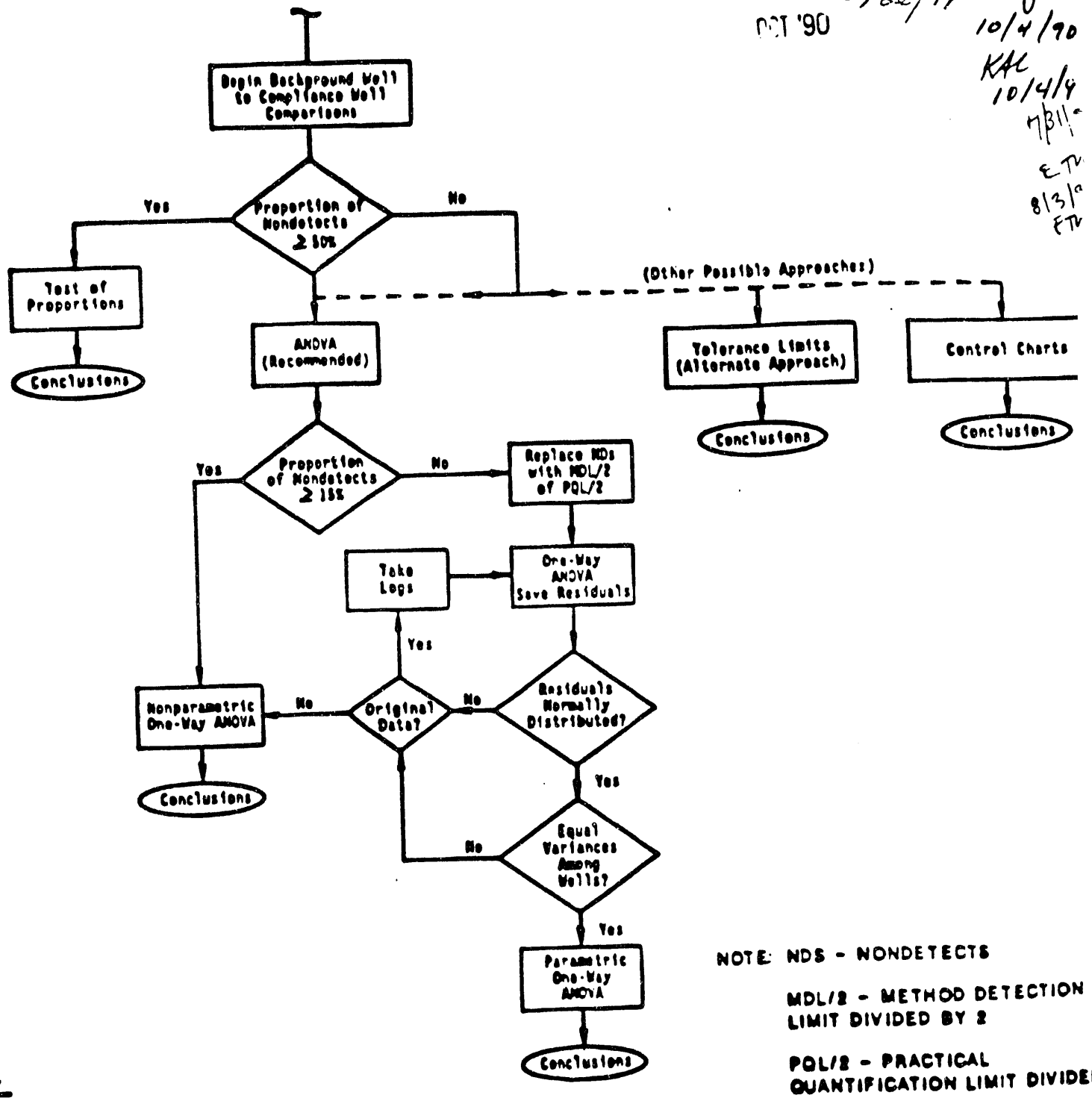

NOTE: NDS - NONDETECTS

MDL/2 - METHOD DETECTION LIMIT DIVIDED BY 2

PQL/2 - PRACTICAL QUANTIFICATION LIMIT DIVIDED BY 2

Adapted from: EPA, 1989

FIGURE ~~4.8~~ 1

STATISTICAL PROCEDURE FOR ASSESSING GROUNDWATER CONTAMINATIO
(CONCLUDED)

TABLE (2)

COPPER CONCENTRATIONS FOR DOWNGRADIENT ALLUVIUM MONITOR WELLS 606 AND 608
AND BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
04/07/88 TO 10/30/90
REPORT DATE: 07/24/91

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	PARAMETER VALUE	PARAMETER FLAGS	DETECTION LIMIT	PARAMETER UNCERTAINTY
COPPER	0606	04/07/88	0001	AL	D	MG/L		0.02		0.02	-
	0606	07/01/88	0001	AL	D		<	0.02		0.02	-
	0606	10/09/88	0001	AL	D		<	0.02		0.02	-
	0606	04/05/89	0001	AL	D		<	0.02		0.02	-
	0606	07/15/89	0001	AL	D		<	0.02		0.02	-
	0606	10/26/89	0001	AL	D		<	0.01		0.02	-
	0606	11/21/89	0001	AL	D		<	0.02		0.02	-
	0606	01/07/90	0001	AL	D		<	0.02		0.02	-
	0608	04/07/88	0001	AL	D			0.02		0.02	-
	0608	07/01/88	0001	AL	D		<	0.02		0.02	-
	0608	10/09/88	0001	AL	D		<	0.02		0.02	-
	0608	01/08/89	0001	AL	D		<	0.02		0.02	-
	0608	04/04/89	0001	AL	D		<	0.02		0.02	-
	0608	07/15/89	0001	AL	D		<	0.02		0.02	-
	0608	10/26/89	0001	AL	D		<	0.01		0.02	-
	0608	11/16/89	0001	AL	D		<	0.02		0.02	-
	0608	01/05/90	0001	AL	D		<	0.02		0.02	-
	0608	02/22/90	0001	AL	D		<	0.01		0.02	-
	0608	10/30/90	0001	AL	D		<	.02		0.02	-
	0623	10/27/89	0001	AL	U			0.01	c	0.01	-
	0623	01/06/90	0001	AL	U		<	0.02		0.02	-
	0623	02/22/90	0001	AL	U		<	0.01		0.02	-
	0623	07/19/90	0001	AL	U		<	0.01		0.01	-
	0623	09/21/90	0001	AL	U		<	.02		0.02	-
	0623	10/30/90	0001	AL	U		<	.02		0.02	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

OTHER PARAMETER VALUE FLAGS:
c - CHANGED DETECTION LIMIT

DATA FILE NAME: M:\DART\DUR03\GWQ10025.DAT

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In the test of proportions for vanadium, there was no statistically significant evidence at the 5% significance level, that vanadium is a groundwater contaminant in either downgradient monitor well 606 or 608. Given the very low percentage of nondetects for copper in downgradient monitor wells where background concentrations were exceeded, copper is not considered to be a groundwater contaminant in either downgradient monitor well 606 or 608.

RESULTS

There is no statistical evidence that the hazardous constituents vanadium is a groundwater contaminant in the alluvial groundwater related to seepage from the disposal cell or discharges from the holding pond. There is no qualitative evidence that copper is a groundwater contaminant in the alluvial groundwater.

REFERENCES

U.S. EPA, 1989, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities.

ATTACHMENTS

Attachment 1 - Test of Proportions for Vanadium, monitor wells 606, 608, and 623.

JACOBS ENGINEERING

DATE 8/12/91 SUBJECT ATTACHMENT 1 SHEET NO. 29 Caf

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VANADIUM DATA FOR MONITOR WELLS 606, 608, AND 623.

	MW 606	MW 608	MW 623
# SAMPLES:	5	7	6
# DETECTS:	2	4	3

SEE VANADIUM DATA TABLE NEXT PAGE

$P_u = \frac{\#\text{ of detects}(x)}{\#\text{ of samples}(n)}$ for the upgradient monitor well population

$P_d = \frac{\#\text{ of detects}(y)}{\#\text{ of samples}(m)}$ for the downgradient monitor well population

$$S_D = \left\{\left[(x+y)/(n+m)\right]\left[1-(x+y)/(n+m)\right]\left[\frac{1}{n}+\frac{1}{m}\right]\right\}^{1/2}$$

$Z = (P_u - P_d)/S_D$ (absolute value) COMPARE Z TO 1.96, THE 97.5TH PERCENTILE FROM THE STANDARD NORMAL DISTRIBUTION.

MONITOR WELL 623: $P_u = 0.50$ ✓
MONITOR WELL 606: $P_d = 0.40$ ✓
$S_D = 0.30$ ✓
$Z = 0.33$ ✓

MONITOR WELL 623: $P_u = 0.50$ ✓
MONITOR WELL 608: $P_d = 0.57$ ✓
$S_D = 0.29$ ✓
$Z = 0.24$ ✓

$0.33 \neq 1.96$ ✓ $0.24 \neq 1.96$ ✓

THEREFORE, THERE IS STATISTICAL EVIDENCE AT THE 5% SIGNIFICANCE LEVEL THAT THE PROPORTION OF DOWNGRADIENT SAMPLES IN 606 OR 608 OF VANADIUM DETECTS DOES NOT EXCEED THE PROPORTION OF BACKGROUND (623) SAMPLES OF VANADIUM DETECTS. THEREFORE, THERE IS NO STATISTICAL EVIDENCE OF VANADIUM CONTAMINATIC IN DOWNGRADIENT MONITOR WELLS 606 AND 608.

ATTACHMENT 1 CONT.

VANADIUM CONCENTRATIONS IN GROUNDWATER: MONITOR WELLS 606, 608, AND 623
DURANGO DISPOSAL SITE, DURANGO COLORADO
SITE: DUR03 BODO CANYON
04/04/89 TO 10/30/90
REPORT DATE: 08/13/91

PARAMETER NAME	LOCATION ID	LOG DATE	SAMPLE ID	FORM COMP	FLOW REL.	UNITS OF MEASURE	PARAMETER PVI	PARAMETER VALUE	FLAGS	DETECTION LIMIT	PARAMETER UNCERTAINTY
VANADIUM	0606	04/05/89	0001	AL	D	MG/L		0.05		0.01	-
	0606	07/15/89	0001	AL	D			.05		0.01	-
	0606	10/26/89	0001	AL	D		<	0.01		0.01	-
	0606	11/21/89	0001	AL	D		<	0.01		0.01	-
	0606	01/07/90	0001	AL	D		<	0.01		0.01	-
	0608	04/04/89	0001	AL	D			0.03		0.01	-
	0608	07/15/89	0001	AL	D			0.04		0.01	-
	0608	10/26/89	0001	AL	D		<	0.01		0.01	-
	0608	11/16/89	0001	AL	D		<	0.01		0.01	-
	0608	01/05/90	0001	AL	D			0.02		0.01	-
	0608	02/22/90	0001	AL	D		<	0.01		0.01	-
	0608	10/30/90	0001	AL	D			.02		0.01	-
	0623	10/27/89	0001	AL	U			0.01		0.01	-
	0623	01/06/90	0001	AL	U		<	0.01		0.01	-
	0623	02/22/90	0001	AL	U		<	0.01		0.01	-
	0623	07/19/90	0001	AL	U		<	0.01		0.01	-
	0623	09/21/90	0001	AL	U			.02		0.01	-
	0623	10/30/90	0001	AL	U			.02		0.01	-

FORMATION OF COMPLETION CODE:
AL - ALLUVIUM

FLOW RELATIONSHIP CODE:
D - DOWN GRADIENT
U - UPGRADIENT

PARAMETER VALUE INDICATOR (PVI): < - LESS THAN DETECTION LIMIT

SAMPLE ID CODES:
0001 - FILTERED SAMPLE (.45 MICRONS)

DATA FILE NAME: M:\DART\DUR03\GWQ10027.DAT

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JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

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CALC NO. DUR03-02-91-14-10-00 DISCIPLINE HYDRO NO. OF SHEETS ~~22~~

PROJECT: UMTRA

SITE: DURANGO DISPOSAL SITE

FEATURE: DETERMINATION OF ALLUVIAL BACKGROUND GROUNDWATER QUALITY

SOURCES OF DATA:

UMTRA DART DATA MANAGEMENT SYSTEM

SOURCES OF FORMULAE & REFERENCES:

US EPA, 1989, Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities.

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO. DUR03-09-90-14-10

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		Clark Gore	2/19/91	R Heydenberg	22 Feb 91	KB	3/25/91
01	update of data table & revised report			TOD MINES	7/31/91	KB	
		Clark Gore	7/24/91				

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DURANGO CALCULATION DUR03-02-91-14-10-00

DETERMINATION OF ALLUVIAL BACKGROUND GROUNDWATER QUALITY, DURANGO DISPOSAL SITE

PROBLEM STATEMENT

This calculation was performed to characterize background groundwater quality by defining mean, statistical maximum, and maximum observed values of constituents in the alluvium. The background concentrations of the alluvium groundwater are used to compare with concentrations observed in the alluvium downgradient of the disposal cell to determine if groundwater in this unit has been impacted by the diposal cell seepage face or retention pond discharges.

PROCEDURE

Groundwater quality data from monitor well 623 represents background groundwater quality for the alluvium (Figure 1). These data were retrieved from the UMTRA DART data management system. The DART software then performed statistical operations on the retrieved data.

ASSUMPTIONS

It is assumed that monitor well 623 samples represent background groundwater quality for the alluvium in Bodo basin. Monitor well 623 is located in a sub-basin to Bodo basin.

DATA SOURCES

All data used in this statistical analysis were obtained from the UMTRA DART data management system.

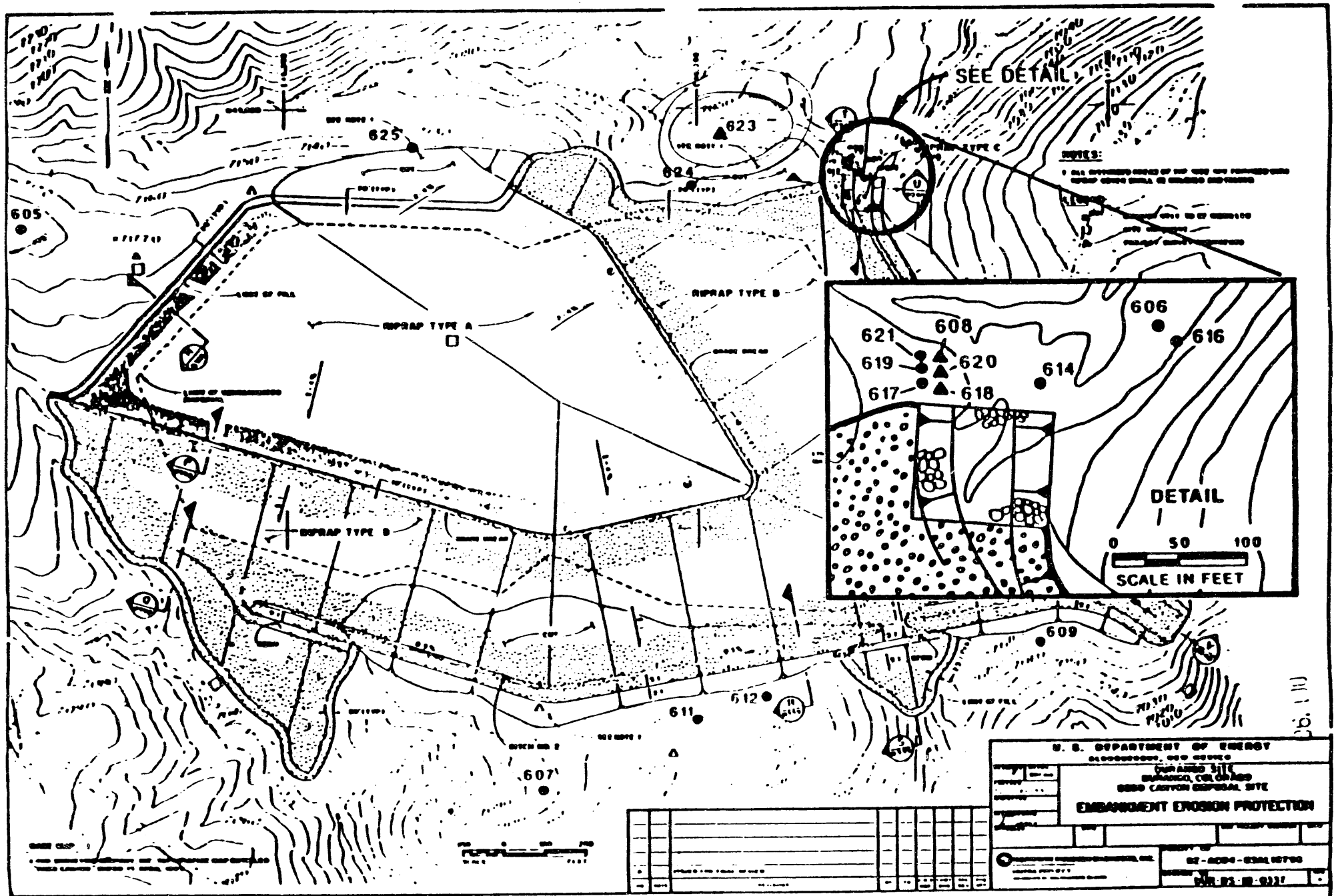
SOLUTION

The statistics of the background groundwater quality in the alluvium at the Durango Disposal Site are included as a Table in Attachment 1. These tables list the constituent, number of samples, minimum and maximum observed, mean, median, standard deviation, percent of nondetects, statistical range (99% one sided confidence interval stat. min. and stat. max.) and the distribution type.

CONCLUSIONS/RESULTS

Attachment 1 lists the hazardous constituent, laboratory method detection limit, mean, observed maximum, 99% confidence interval, and the defined statistical maximum.

Maximum concentrations of molybdenum, and activities of net gross alpha, and radium-226 and -228 have exceeded MCLs at least once in



LEGEND
● BEDROCK MONITOR WELL
▲ ALLUVIAL MONITOR WELL

FIGURE # 1
WELL LOCATIONS, BODO CANYON DISPOSAL SITE

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background alluvial monitor well 623. This may indicate that concentrations greater than MCLs for these constituents are naturally occurring in the alluvial groundwater.

REFERENCES FOR PROCEDURES

Technical Approach Document (JEG, 1989)

Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Draft) (EPA, 1989)

ATTACHMENTS

Attachment 1 - Groundwater Quality Statistics by Parameter, Monitor Well 623

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
ALKALINITY	MG/L CACO3	6	441.0000	2892.0000	476.5000	645.9254	2.0968	NA	0.0	233.5881	1786.1338	LOGNORMAL	7,8
ALUMINUM	MG/L	2	0.0500	0.0500	0.0500	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
AMMONIUM	MG/L	1	0.5000	0.5000	0.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
ANTIMONY	MG/L	6	0.0015	0.0100	0.0015	NA	NA	NA	83.3	0.0015	0.0100	NONPARAMETRIC	2,6
ARSENIC	MG/L	6	0.0020	0.0150	0.0050	NA	NA	NA	83.3	0.0020	0.0150	NONPARAMETRIC	2,6
BARIUM	MG/L	6	0.0300	0.1400	0.0500	NA	NA	NA	50.0	0.0300	0.1400	NONPARAMETRIC	2,6
BERYLLIUM	MG/L	6	0.0025	0.0050	0.0025	NA	NA	NA	100.0	0.0025	0.0050	NONPARAMETRIC	2,6
CADMIUM	MG/L	6	0.0002	0.0005	0.0005	NA	NA	NA	83.3	0.0002	0.0005	NONPARAMETRIC	2,6
CALCIUM	MG/L	6	226.0000	284.0000	249.5000	253.0000	19.7585	0.0781	0.0	225.8566	280.1434	NORMAL	
CHLORIDE	MG/L	6	14.0000	40.5000	38.0000	34.4167	10.2099	0.2967	0.0	20.3908	48.4425	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

Attachment 1

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL			
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
CHROMIUM			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
COBALT			MG/L								
6	0.0100	0.0250	0.0250	NA	NA	NA	83.3	0.0100	0.0250	NONPARAMETRIC	2,6
COPPER			MG/L								
6	0.0050	0.0100	0.0100	NA	NA	NA	83.3	0.0050	0.0100	NONPARAMETRIC	2,6
CYANIDE			MG/L								
3	0.0050	0.0050	0.0050	NA	NA	NA	100.0	NA	NA	UNKNOWN	1
FLUORIDE			MG/L								
6	0.2000	0.5000	0.4500	0.4000	0.1265	0.3162	0.0	0.2262	0.5738	NORMAL	
GROSS ALPHA			PCI/L								
4	0.5000	23.8000	1.5000	NA	NA	NA	50.0	0.5000	23.8000	NONPARAMETRIC	2,4
GROSS BETA			PCI/L								
6	8.0000	33.8000	10.0500	15.0167	10.0921	0.6721	0.0	1.1526	28.8807	NORMAL	
IRON			MG/L								
6	0.0150	0.9000	0.2600	NA	NA	NA	33.3	0.0150	0.9000	NONPARAMETRIC	2,6
LEAD			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
MAGNESIUM			MG/L								
6	195.0000	227.0000	214.0000	212.8333	12.4486	0.0585	0.0	195.7321	229.9346	NORMAL	

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
MANGANESE	MG/L	6	0.3900	0.9800	0.6550	0.6400	0.2096	0.3275	0.0	0.3521	0.9279	NORMAL	
MERCURY	MG/L	6	0.0001	0.0001	0.0001	NA	NA	NA	100.0	0.0001	0.0001	NONPARAMETRIC	2,6
MOLYBDENUM	MG/L	6	0.0050	0.2000	0.0230	NA	NA	NA	33.3	0.0050	0.2000	NONPARAMETRIC	2,6
NET GROSS ALPHA ***	PCI/L	4	-0.5300	22.4300	0.4700	NA	NA	NA	0.0	-0.5300	22.4300	NONPARAMETRIC	9,4
NICKEL	MG/L	6	0.0200	0.0200	0.0200	NA	NA	NA	100.0	0.0200	0.0200	NONPARAMETRIC	2,6
NITRATE	MG/L	6	0.4000	2.2000	0.5000	NA	NA	NA	50.0	0.4000	2.2000	NONPARAMETRIC	2,6
NITRITE AND NITRATE	MG/L	1	0.4700	0.4700	0.4700	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
POTASSIUM	MG/L	6	2.9000	11.0000	3.7000	4.9000	3.0874	0.6301	0.0	0.6587	9.1413	NORMAL	
RADIUM-226	PCI/L	6	0.0500	34.9000	0.1500	NA	NA	NA	16.7	0.0500	34.9000	NONPARAMETRIC	2,6

*** NET GROSS ALPHA (GROSS ALPHA - URANIUM) WITH 1 MG URANIUM = 686 PCI
* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
9) The nonparametic distribution was used because the data failed the normal distribution test and includes values ≤0.

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7/31/91
7/31/91

GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME			UNITS					STATISTICAL RANGE 98% CONFIDENCE INTERVAL		DISTRIBUTION TYPE	FOOT NOTE
# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	MINIMUM	MAXIMUM *		
RADIUM-226 + RADIUM-228			PCI/L								
6	1.0000	35.4000	1.4750	2.6551	3.8085	NA	0.0	0.4229	16.6685	LOGNORMAL	7,8
RADIUM-228			PCI/L								
6	0.5000	3.3000	1.3000	NA	NA	NA	16.7	0.5000	3.3000	NONPARAMETRIC	2,6
REDOX POTENTIAL			MVOLTS								
1	185.6000	185.6000	185.6000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SELENIUM			MG/L								
6	0.0010	0.0150	0.0025	NA	NA	NA	100.0	0.0010	0.0150	NONPARAMETRIC	2,6
SILVER			MG/L								
6	0.0050	0.0050	0.0050	NA	NA	NA	100.0	0.0050	0.0050	NONPARAMETRIC	2,6
SODIUM			MG/L								
6	114.0000	176.0000	167.0000	159.5000	22.9151	0.1437	0.0	128.0203	190.9797	NORMAL	
SPECIFIC CONDUCTANCE			UMHO/CM								
6	100.0000	1860.0000	1675.0000	1242.1667	762.9523	0.6142	0.0	194.0568	2290.2765	NORMAL	
STRONTIUM			MG/L								
2	2.2000	2.2000	2.2000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
SULFATE			MG/L								
6	1299.0000	1360.0000	1330.0000	1331.5000	28.0980	0.0211	0.0	1292.9002	1370.0998	NORMAL	
SULFIDE			MG/L								
4	0.0500	8.0000	0.4000	NA	NA	NA	25.0	0.0500	8.0000	NONPARAMETRIC	2,4

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
4) The stat. range is the 87.5% confidence interval due to a sample size of 4. The maximum is the 93.8% one sided confidence int.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.
7) The lognormal distribution was used because the data failed the normal distribution test.
8) The mean is geometric. The standard deviation is the value to divide or multiply with the geometric mean.

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GROUNDWATER QUALITY STATISTICS BY PARAMETER
BACKGROUND MONITOR WELL 623
SITE: DUR03 BODO CANYON
10/27/89 TO 10/30/90
REPORT DATE: 07/23/91

PARAMETER NAME	UNITS	# OF SAMP	MINIMUM	MAXIMUM	MEDIAN	MEAN	STANDARD DEVIATION	COEFF. OF VARIATION	% OF NON DETECTS	STATISTICAL RANGE 98% CONFIDENCE INTERVAL MINIMUM	MAXIMUM *	DISTRIBUTION TYPE	FOOT NOTE
TEMPERATURE	C - DEGREE	6	6.0000	9.5000	9.0000	8.0833	1.6253	0.2011	0.0	5.8505	10.3161	NORMAL	
THALLIUM	MG/L	6	0.0005	0.0500	0.0100	NA	NA	NA	100.0	0.0005	0.0500	NONPARAMETRIC	2,6
TIN	MG/L	6	0.0025	0.0250	0.0085	NA	NA	NA	50.0	0.0025	0.0250	NONPARAMETRIC	2,6
TOTAL DISSOLVED SOLIDS	MG/L	6	2240.0000	2440.0000	2340.0000	2349.6667	67.8872	0.0289	0.0	2256.4063	2442.9270	NORMAL	
TOTAL ORGANIC CARBON	MG/L	2	10.0000	33.0000	21.5000	NA	NA	NA	0.0	NA	NA	UNKNOWN	1
URANIUM	MG/L	6	0.0011	0.0020	0.0015	NA	NA	NA	50.0	0.0011	0.0020	NONPARAMETRIC	2,6
VANADIUM	MG/L	6	0.0050	0.0200	0.0075	NA	NA	NA	50.0	0.0050	0.0200	NONPARAMETRIC	2,6
ZINC	MG/L	6	0.0025	0.0400	0.0025	NA	NA	NA	83.3	0.0025	0.0400	NONPARAMETRIC	2,6

* The statistical maximum is the 99 percent one sided confidence interval, $\alpha = 0.01$
1) A minimum of 4 samples must be available for the statistical analysis.
2) The nonparametric distribution was used because the nondetected values comprise more than 15% of the samples.
6) The stat. range is the 96.9% confidence interval due to a sample size of 6. The maximum is the 98.5% one sided confidence int.

INPUT DATA FILENAME: M:\DART\DUR03\GWQ10023.DAT

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JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. DUR03-05-91-13-01-00 DISCIPLINE HYDRO NO. OF SHEETS 4

PROJECT:
UMTRA

SITE:
DURANGO DISPOSAL SITE

FEATURE:
AREA OF (DISPOSAL SITE) BODO BASIN COVERED BY THE DISPOSAL CELL.

SOURCES OF DATA:
MKE DESIGN DRAWING "EMBANKMENT FINAL GRADING" (NO. DUR-DS-10-0335)
MKE DESIGN DRAWING "EMBANKMENT FOUNDATION EXCAVATION (NO. DUR-DS-10-0334)

SOURCES OF FORMULAE & REFERENCES:
N/A

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO. ____

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		[illegible]	5/2/91	E Tidwell/KS	5/16/91		
1	Revised wording pgs 1/4 to 4/4	[illegible]	7/22/91	[illegible]	[illegible]	[illegible]	7/22/91

Cap 1/4 5/8/91

ETM 5/10/91

KAL 7/2/91

DURANGO CALCULATION DUR03-05-91-13-01-00

AREA OF BODO BASIN (DISPOSAL SITE) COVERED BY THE DISPOSAL CELL AND RELATED FEATURES

PURPOSE:

The purpose of this calculation is to determine the total area of surface drainage into Bodo Basin and the percentage of this area covered by the Durango Disposal Cell, surrounding drainages, and other excavated areas. This is done to quantify the extent of alluvial material from which recharge by precipitation is eliminated.

METHOD:

The total area of surface drainage into Bodo Canyon basin will be delineated on a topographic map of the Bodo basin area. This area of surface drainage will be determined with a planimeter. The total area of the disposal cell and related features inside the area of surface drainage will then be determined by planimeter. The percentage of disposal cell coverage will be determined by dividing the the disposal cell area by the total surface drainage area.

ASSUMPTIONS:

It is assumed that the disposal cell design and topography are accurately depicted on the referenced design drawings.

DATA SOURCES:

Remedial Action Contractor (RAC) design drawing "EMBANKMENT FINAL GRADING" (DUR-DS-10-0335).

RAC design drawing "EMBANKMENT FOUNDATION EXCAVATION" (DUR-DS-10-0334).

SOLUTION:

The Bodo basin drainage divide is delineated on the topography in Figure 1. The disposal cell final grading including all related features plus the drainage divide is shown in Figure 2. The planimetered area of surface drainage is 62.54 square inches. The planimetered area of the disposal cell and related features inside the surface drainage area is 53.11 square inches.

53.11/62.54 x 100 = 84.9% ✓✓

CONCLUSIONS:

85% of Bodo basin drainage area is covered with the disposal cell, associated drainage ditches, and surface excavations to bedrock. The remaining 15% of the area not covered by the disposal cell is

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in topographically high areas where the alluvium is absent. ETM

RESULTS: 7/21

15% of the Bodo basin drainage area is not covered by the disposal cell. These areas are topographically high and covered by a thin layer of soil. Alluvial deposits are not present in these areas. Precipitation that does infiltrate these areas most likely enters the bedrock as unsaturated flow. Therefore, 85% to 100% of precipitation recharge to the Bodo basin alluvium is eliminated by the disposal cell construction. KAL 7/21

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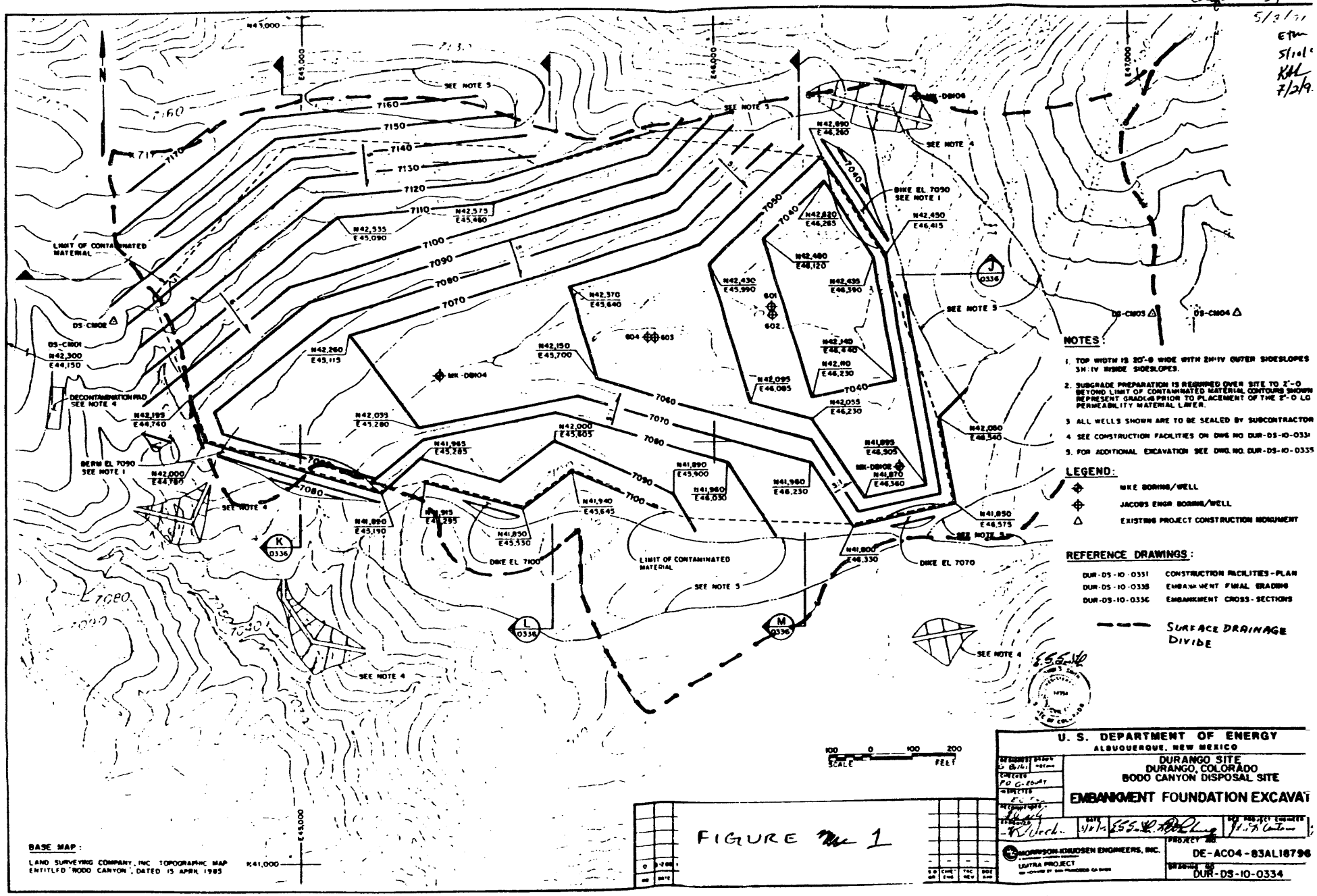
5/3/91
ETM
5/10/9
KHL
7/2/9



NOTES:

1. TOP WIDTH IS 20'-0 WIDE WITH 2H:1V OUTER SIDESLOPES 3H:1V INSIDE SIDESLOPES.
2. SUBGRADE PREPARATION IS REQUIRED OVER SITE TO 2'-0 BEYOND LIMIT OF CONTAMINATED MATERIAL CONTOURS SHOWN REPRESENT GRADES PRIOR TO PLACEMENT OF THE 2'-0 LO PERMEABILITY MATERIAL LAYER.
3. ALL WELLS SHOWN ARE TO BE SEALED BY SUBCONTRACTOR
4. SEE CONSTRUCTION FACILITIES ON DWG NO DUR-DS-10-0331
5. FOR ADDITIONAL EXCAVATION SEE DWG. NO. DUR-DS-10-0335

LEGEND:

- MKE BORING/WELL
- JACOBS ENGR BORING/WELL
- EXISTING PROJECT CONSTRUCTION MONUMENT

REFERENCE DRAWINGS:

DUR-DS-10-0331	CONSTRUCTION FACILITIES-PLAN
DUR-DS-10-0335	EMBANKMENT FINAL GRADING
DUR-DS-10-0336	EMBANKMENT CROSS-SECTIONS

SURFACE DRAINAGE DIVIDE

FIGURE No 1

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DURANGO SITE
DURANGO, COLORADO
BODO CANYON DISPOSAL SITE

EMBANKMENT FOUNDATION EXCAVAT

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO DE-AC04-83AL18796

DRAWING NO DUR-DS-10-0334

TABLE I						
CURVE	CURVE DATA				P I COORDINATES	
	Δ	R	T	L	NORTH	EAST
A	50°37'38"	677.08'	320.25'	598.27'	42,384.98	44,851.21
B	41°25'52"	600.00'	226.91'	433.86'	41,642.82	45,568.24
1	45°00'00"	350.00'	145.00'	274.90'	42,056.04	44,844.80
2	41°25'52"	600.00'	226.90'	433.90'	41,604.79	45,562.27
3 N EDGE	45°00'00"	300.00'	124.26'	235.60'	41,881.31	47,039.89
3 S EDGE	45°00'00"	300.00'	124.26'	235.60'	41,854.12	46,947.21

(CONTINUED IN NOTES)

7 NORTHERN LIMIT OF CONTAMINATED MATERIAL (BETWEEN E 44,610 AND E 45,550 APPROXIMATELY) VARIES DEPENDING ON FINAL QUANTITIES PLACED IN THE EMBANKMENT

8 EXCAVATION WILL BE DEPENDENT ON FINAL ELEVATION OF EMBANKMENT SUCH THAT DRAINAGE AWAY FROM THE EMBANKMENT IS MAXIMIZED

NOTES:

1 THE ACTUAL LOCATION OF THE GRADE BREAK BETWEEN THE EMBANKMENT TOP AND THE 3:1 SIDESLOPES WILL VARY BETWEEN EL 7110 AND 7190 DEPENDING ON THE AMOUNT OF CONTAMINATED MATERIAL PLACED IN THE EMBANKMENT. THE EMBANKMENT SHOWN WILL HOLD APPROXIMATELY 2.7 MILLION CUBIC YARDS OF CONTAMINATED MATERIAL

2 SUBCONTRACTOR SHALL CLEAR AND GRUB ALL AREAS WITHIN THE LIMITS OF FINAL EMBANKMENT GRADING.

3 FILL SHALL BE PLACED TO BLEND WITH EXISTING GROUND.

4 PERMANENT BOUNDARY SIGNS SHALL BE PLACED AROUND PERIMETER OF EMBANKMENT AS INSTRUCTED BY THE CONTRACTOR

5 EXISTING CHANNEL SHALL BE WIDENED TO 50 FEET FOR A DISTANCE OF APPROXIMATELY 200 FEET BEYOND THE TOE OF FILL (SEE SECTION 5 ON DWG NO DUR-DS-10-0339)

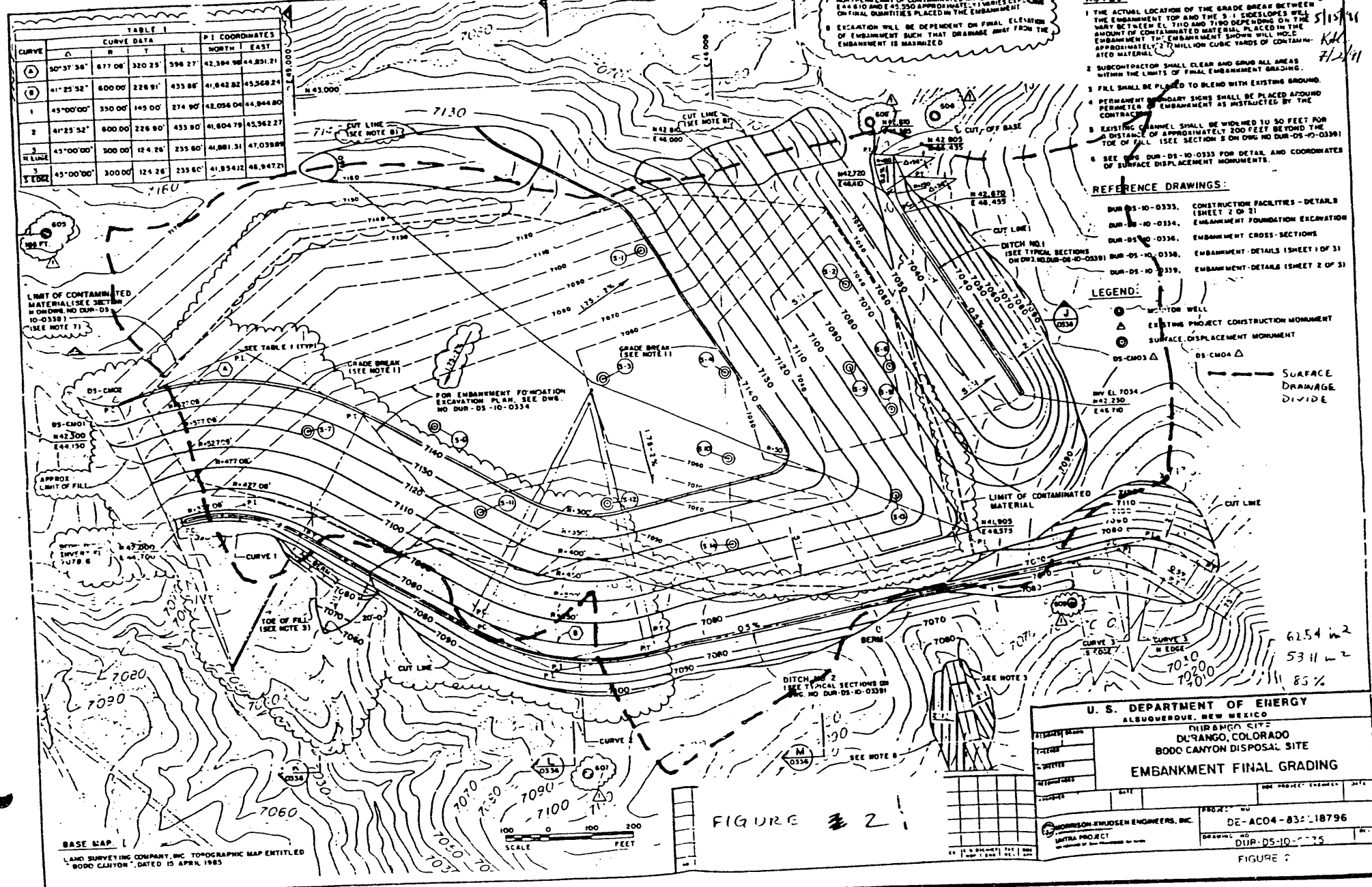
6 SEE DWG DUR-DS-10-0333 FOR DETAIL AND COORDINATES OF SURFACE DISPLACEMENT MONUMENTS.

REFERENCE DRAWINGS:

DUR-DS-10-0333,	CONSTRUCTION FACILITIES - DETAILS (SHEET 2 OF 2)
DUR-DS-10-0334,	EMBANKMENT FOUNDATION EXCAVATION
DUR-DS-10-0336,	EMBANKMENT CROSS-SECTIONS
DUR-DS-10-0338,	EMBANKMENT DETAILS (SHEET 1 OF 3)
DUR-DS-10-0339,	EMBANKMENT DETAILS (SHEET 2 OF 3)

LEGEND:

- MONITOR WELL
- EXISTING PROJECT CONSTRUCTION MONUMENT
- SURFACE DISPLACEMENT MONUMENT
- SURFACE DRAINAGE DIVIDE



BASE MAP: LAND SURVEYING COMPANY, INC. TOPOGRAPHIC MAP ENTITLED "BODO CANYON", DATED 15 APRIL 1985

FIGURE 2

U. S. DEPARTMENT OF ENERGY
ALBUQUERQUE, NEW MEXICO

DURANGO SITE
DURANGO, COLORADO
BODO CANYON DISPOSAL SITE

EMBANKMENT FINAL GRADING

MORRISON-KNUDSEN ENGINEERS, INC.
UMTRA PROJECT

PROJECT NO. DE-AC04-83-18796

DRAWING NO. DUR-DS-10-0335

FIGURE 2

JACOBS ENGINEERING GROUP INC.
ADVANCED SYSTEMS DIVISION, ALBUQUERQUE OPERATIONS

CALCULATION COVER SHEET

CALC NO. DUR03-05-91-12-01-00 DISCIPLINE HYDRO NO. OF SHEETS 14

PROJECT:
UMTRA

SITE:
DURANGO DISPOSAL SITE

FEATURE:
DETERMINATION OF ALLUVIUM RECHARGE CHANGE IN RESPONSE TO DURANGO DISPOSAL CELL CONSTRUCTION

SOURCES OF DATA:
NOAA, National Climatic Data Center
DURANGO RAP, Nov. 1990

SOURCES OF FORMULAE & REFERENCES:
N/A

PRELIMINARY CALC. ☑ FINAL CALC. ☐ SUPERSEDES CALC. NO.

REV. NO.	REVISION	CALCULATION BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
		Clark Boone	5/10/91	E Tolmachev	5/15/91		
1	REVISED % INFILTRATION Pgs. 2/14 & 3/14	Clark Boone	7/1/91	[illegible]	[illegible]	KS	7/22/91

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9/1/91
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7/2/91

DURANGO CALCULATION DUR03-05-91-12--01-00

DETERMINATION OF ALLUVIUM RECHARGE CHANGE
IN RESPONSE TO DURANGO DISPOSAL CELL CONSTRUCTION

PURPOSE:

The purpose of this calculation is to determine the effect of the Durango disposal cell on recharge entering the alluvium and soil beneath the disposal cell by comparing the volume of pre-disposal cell natural recharge with disposal cell transient drainage and steady-state drainage.

METHOD:

The natural precipitation recharge in acre-feet/year, for the area of Bodo basin now covered by the Durango disposal cell will be calculated using the disposal area, the average annual precipitation, and an assumption that 10% of the rainfall infiltrates. Recharge from the Durango disposal cell transient drainage and steady-state drainage will be calculated in acre-feet/year using the disposal cell liner hydraulic conductivity and disposal cell area. The two rates will then be compared to determine the change in recharge rate to the underlying alluvium and soils due to disposal cell construction.

ASSUMPTIONS:

It is assumed the precipitation record for the city of Durango is applicable to the Bodo basin which is approximately two miles to the southwest.

It is assumed the calculated hydraulic conductivity of the disposal cell liner material is applicable to the entire area of the disposal cell.

It is assumed that 10% of the total rainfall infiltrates the soil. Despite the high lake evaporation rate (42 inches), infiltration must occur due to snowmelt and intense thunderstorms since alluvial saturation was observed in the northeast prior to disposal cell construction. Since Bodo Canyon is a closed basin, overland flow from these two sources would likely travel towards and pond in the center and northeast areas of the basin. Which would cause infiltration in these areas.

DATA SOURCES:

Precipitation data (years 1951 - 1989) for the Durango area were obtained from the National Atmospheric and Oceanic Administration (NOAA), National Climatic Data Center, Asheville, North Carolina.

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The RAC monitored rainfall at the disposal site from April 1988 through November 1990. This record is not of suffient duration to calculate a meaningful average annual preciptitation rate. The one complete annual record for the disposal site (1989) showed 0.4 inches more precipitation than was recorded in the city of Durango.

The evaporation rate was obtained from the Durango Environmental Impact Statement (DOE, 1985).

The disposal cell area was obtained from the Durango Preliminary Revised Final RAP, November 1990. The disposal cell liner material hydraulic conductivity was obtained from TAC engineering calculation DUR03-09-90-12-01-00 (Durango pfRAP, Nov. 1990).

The net flux through the disposal cell cover was obtained from TAC calculation DUR-02-89-13-03-06-00.

SOLUTION:

The average annual precipitation for the Durango area is 18.61 inches. The disposal cell area is approximately 32 acres. The disposal cell liner hydraulic conductivity is 1.6×10^{-8} cm/s which will be used for the transient recharge rate. The disposal cell cover flux (including topslope and sideslopes) is 3×10^{-9} cm/s which will be used for the steady-state recharge rate.

NATURAL RECHARGE:

$$18.61 \text{ in/yr} \times .10 \times \frac{1}{12} \text{ ft/in.} \times 32 \text{ acres} =$$

$$\underline{4.96 \text{ acre feet/year}} \checkmark$$

TRANSIENT DRAINAGE:

$$1.6 \times 10^{-8} \text{ cm/s} \times 3.15 \times 10^{7} \text{ sec/yr} \times \frac{1}{30.48} \text{ ft/cm} \times 32 \text{ acres} =$$

$$\underline{0.53 \text{ acre feet/year}} \checkmark$$

$$\text{RATIO } \frac{\text{NATURAL RECHARGE}}{\text{TRANSIENT DRAINAGE}} = \frac{4.96}{0.53} = \underline{9.4 \text{ TIMES}} \checkmark$$

STEADY-STATE DRAINAGE:

$$3 \times 10^{-9} \text{ cm/s} \times 3.15 \times 10^{7} \text{ sec/yr} \times \frac{1}{30.48} \text{ ft/cm} \times 32 \text{ acres} =$$

$$\underline{0.1 \text{ acre feet/year}} \checkmark$$

$$\text{RATIO } \frac{\text{NATURAL RECHARGE}}{\text{STEADY-STATE DRAINAGE}} = \frac{4.96}{0.1} = \underline{49.6 \text{ TIMES}} \checkmark$$

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CONCLUSIONS and RESULTS:

By comparing the transient drainage from the Durango disposal cell to the natural precipitation recharge it has been shown that recharge to the alluvium and soils underlying the disposal cell area has been reduced by 9.4 times due to construction of the disposal cell. By comparing the steady-state drainage from the Durango disposal cell to the natural precipitation recharge it has been shown that recharge will be reduced by 49.6 times due to the disposal cell influence.

REFERENCES:

DOE, 1985, Final Environmental Impact Statement Remedial Actions at the Former Vanadium Corporation of America Uranium Mill Site Durango, La Plata County, Colorado, Uranium Mill Tailing Remedial Action Project, Albuquerque Operations Office, Albuquerque, New Mexico.

DOE, 1990, Remedial Action Plan and Site Design for Stabilization of the Inactive Uranium Mill Tailings Site at Durango, Colorado, Attachment 3, Groundwater Hydrology Report, Preliminary Revised Final, Uranium Mill Tailings Remedial Action Project, Albuquerque Operations Office, Albuquerque, New Mexico.

ATTACHMENTS:

Annual Climatological Summary, Durango Colorado, 1951 - 1989.

JACOBS ENGINEERING

DATE 5/15/91 SUBJECT

BY ETM CHKD. ✓

SHEET NO. 7/14 5/10/91 CCB

JOB NO. KAL 7/2/9.

ATTACHMENT 1

ANNUAL CLIMATOLOGICAL SUMMARY, DURANGO, CO.

FORM 91-005-1 (4/81)

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)														PRECIPITATION (INCHES)									
												NUMBER OF DAYS								SNOW, SLEET			NO. OF DAYS		
YR.	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
89	1	38.2	7.7	23.0	-2.7	1296	0	48	22•	-11	8	0	6	31	10	1.88	-.07	.72	4	22.7	13	29•	6	1	0
89	2	44.6	18.5	31.6	.8	933	0	65	25	-10	7	0	3	28	2	1.29	.00	.54	4	15.0	17	8•	2	2	0
89	3	60.0	27.1	43.6	6.4	660	0	75	10•	15	5	0	0	29	0	.95	-.57	.36	26	2.0	1	2	3	0	0
89	4	69.8	33.0	51.4	6.4	401	0	81	21	24	30	0	0	14	0	.00T	-1.21	.00	30•	.0	0		0	0	0
89	5	77.0	37.2	57.1	3.9	237	0	86	28•	26	1	0	0	5	0	.26	-.82	.22	16	.0	0		1	0	0
89	6	84.3	43.5	63.9	2.4	76	51	97	18	35	1	6	0	0	0	.11	-.48	.04	12•	.0	0		0	0	0
89	7	90.3	51.7	71.0	2.7	2	195	102	5	44	3	20	0	0	0	3.26	1.56	1.36	26	.0	0		7	2	1
89	8	84.5	48.2	66.4	.2	19	68	90	29•	38	25	2	0	0	0	.92	-1.46	.39	12	.0	0		4	0	0
89	9	81.6	41.4	61.5	2.7	106	7	89	2•	34	15•	0	0	0	0	.98	-.54	.44	19	.0	0		4	0	0
89	10	66.0	30.0	48.0	-1.1	520	0	81	12	11	30	0	0	19	0	1.55	-.52	1.24	4	.3	0		2	1	1
89	11	56.8	19.4	38.1	1.0	798	0	70	12	6	29	0	0	30	0	.00T	-1.34	.00	30•	.0	0		0	0	0
89	12	45.9	10.6	28.3	.5	1132	0	55	5	2	12	0	0	31	0	.00T	-1.96	.00	31•	.0T	0T	31•	0	0	0
	ANN.	66.6	30.7	48.7	1.9	6180	321	102	JUL	-11	JAN	28	9	187	12	11.20	-7.41	1.36	JUL	40.0	17	FEB	29	6	2

NORMAL:
11.2 + 7.41 =
18.61 ✓

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

• OCCURRED ON ONE OR MORE PREVIOUS DATES DURING THE MONTH.

T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

D ADJUSTED MONTHLY OR ANNUAL VALUE TOTAL CONTAINS ESTIMATED VALUE(S) FOR MISSING DATA.

A ANNUAL PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

P.A.C. DATA: 1990 21.2 2.59 114% of normal
1989 11.60

5/14
5/10/91
5/15/91
7/2/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)							NO. OF DAYS		
																				SNOW, SLEET					
YR.	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
88	1	34.2	5.8	20.0	-5.7	1386	0	50	29•	-9	1	0	11	31	11	2.53	.58	.83	17	33.5	27	18	5	2	0
88	2	47.1	15.3	31.2	.4	973	0	61	26	3	5	0	0	28	0	.90	-.39	.56	2	9.0	16	2	2	1	0
88	3	53.8	20.2	37.0	-.2	859	0	72	26	9	14	0	0	31	0	.28	-1.24	.16	10	5.5	1	10	2	0	0
88	4	64.5	30.8	47.7	2.7	514	0	76	30•	20	1	0	0	18	0	2.18	.97	1.18	16	.9	0		4	1	1
88	5	71.7	35.9	53.8	.6	341	0	87	15	25	7•	0	0	6	0	.73	-.35	.38	18	.0	0		2	0	0
88	6	83.5	46.9	65.2	3.7	46	58	94	21	30	1	6	0	1	0	2.03	1.44	.67	24	.0	0		6	1	0
88	7	87.2	50.8	69.0	.7	1	131	94	13	45	11	12	0	0	0	.86	-.84	.29	18	.0	0		4	0	0
88	8	83.9	51.9	67.9	1.7	5	104	92	14	45	29	2	0	0	0	4.35	1.97	.89	6	.0	0		10	3	0
88	9	76.2	40.7	58.5	-.3	191	5	90	8	30	19	1	0	4	0	1.26	-.26	.43	21	.0	0		4	0	0
88	10	72.2	33.8	53.0	3.9	365	0	83	3	29	27	0	0	15	0	.55	-1.52	M	M	.0	0		1	0	0
88	11	50.3	21.8	36.1	-1.0	864	0	69	4•	7	28	0	0	30	0	1.89	.55	.75	11	9.3	3	25•	6	1	0
88	12	41.1	11.9	26.5	-1.3	1182	0	56	18•	-14	27	0	7	31	6	1.60	-.36	.45	24	28.5	14	26•	6	0	0
	ANN.	63.8	30.5	47.2	.4	6727	298	94	JUL•	-14	DEC	21	18	195	17	19.16	.55	1.18	APR	73.7	27	JAN	52	9	1

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

• OCCURRED ON ONE OR MORE PREVIOUS DATES DURING THE MONTH.

T TRACE

Y INCLUDES TOTAL FOR PREVIOUS MONTH.

D ADJUSTED MONTHLY OR ANNUAL VALUE TOTAL CONTAINS ESTIMATED VALUE(S) FOR MISSING DATA.

A ANNUAL PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

5/10/91
5/15/91
EM
KKC
7/2/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)							NO. OF DAYS		
																				SNOW, SLEET					
YR.	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
87	1	38.9	12.6	25.8	.1	1205	0	53	12	-8	22	0	7	31	2	1.40	-.47	.77	16	19.7	14	16	4	1	0
87	2	44.5	21.1	32.8	2.0	895	0	59	8	1	28	0	1	28	0	2.97	1.68	.65	26	26.5	15	26	6	3	0
87	3	50.4	20.7	35.6	-1.6	906	0	65	6	3	1	0	0	31	0	1.83	.31	.57	15	19.0	9	1	5	2	0
87	4	66.3	31.3	48.8	3.8	478	0	78	26	21	1	0	0	17	0	1.00	-.21	.72	4	3.5	1	4	3	1	0
87	5	69.9	37.3	53.6	.4	346	0	79	31	26	3	0	0	4	0	.98	-.10	.29	23	.0	0		4	0	0
87	6	84.6	43.8	64.2	2.7	37	23	91	14	37	1	3	0	0	0	1.00	.41	.69	8	.0	0		3	1	0
87	7	87.5	47.3	67.4	-.9	14	98	94	24•	39	18•	9	0	0	0	1.51	-.19	.74	17	.0	0		4	1	0
87	8	82.8	49.0	65.9	-.3	44	76	92	19	39	30•	2	0	0	0	3.20	.82	.67	7	.0	0		6	3	0
87	9	77.6	39.5	58.6	-.2	188	1	86	1	31	29	0	0	2	0	.75	-.77	.30	25	.0	0		3	0	0
87	10	69.0	32.4	50.7	1.6	437	0	85	5	22	21•	0	0	14	3	2.38	.31	.81	14	.0	0		6	1	0
87	11	50.1	22.7	36.4	-.7	851	0	66	4	11	28•	0	0	26	0	3.24	1.90	.83	1	2.6	1	26	7	3	0
87	12	38.9	12.9	25.9	-1.9	1205	0	59	4	-6	31	0	9	31	3	1.69	-.27	.35	13	27.2	11	27•	6	0	0
	ANN.	63.4	30.9	47.1	.4	6606	198	94	JUL	-8	JAN	14	17	184	5	22.03	3.42	.83	NOV	98.5	15	FEB	57	16	0

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

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T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

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A ANNUAL PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

1114
5/10/9
5/15/91
ETM
KAL
7/2/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)									
																				SNOW, SLEET			NO. OF DAYS		
YR	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
86	1	48.9	18.2	33.6	7.9	967	0	60	30•	10	8	L	1	31	0	.08	-1.87	.07	15	.5	1	15	0	0	0
86	2	48.5	23.6	36.1	5.3	802	0	71	26•	-3	10	0	2	24	1	1.89	.60	.52	15	17.5	8	13•	5	1	0
86	3	58.7	26.9	42.8	5.6	683	0	74	28	18	18	0	0	28	0	1.08	-.44	.32	10	11.3	3	10	6	0	0
86	4	60.9	30.8	45.9	.9	570	0	75	22•	21	27•	0	0	20	0	2.80	1.59	1.26	1	4.0	1	2	7	2	1
86	5	71.9	35.5	53.7	.5	341	0	83	25	27	12•	0	0	9	0	.96	-.12	.30	3	.3	0		4	0	0
86	6	81.3	45.7	63.5	2.0	70	31	91	17•	38	11•	3	0	0	0	1.34	.75	.63	25	.0	0		4	1	0
86	7	82.8	49.3	66.1	-2.2	24	66	93	31	41	27	6	0	0	0	2.79	1.09	.57	9	.0	0		8	1	0
86	8	85.6	50.9	68.3	2.1	L	117	95	18•	43	30	9	0	0	0	3.33	.95	.86	23	.0	0		11	2	0
86	9	69.3	40.2	54.8	-4.0	299	0	86	6•	31	27	0	0	3	0	2.90	1.38	.95	24	.0	0		8	1	0
86	10	61.7	32.0	46.9	-2.2	556	0	77	5	23	13	0	0	17	0	3.11	1.04	1.58	11	3.0	0		4	2	1
86	11	49.6	23.7	36.7	-.4	844	0	60	3	11	9	0	0	27	0	4.17	2.83	1.90	1	5.0	3	26	8	3	1
86	12	43.9	17.5	30.7	2.9	1058	0	52	4	7	11	0	0	31	0	1.07	-.89	1.08	6	2.3	1	6	1	1	1
	ANN.	63.6M	32.9	48.3	1.5	6222M	214	95M	AUG	-3	FEB	18M	3	190	1	25.52	6.91	1.90	NOV	43.9M	8	FEB	66M	14	4

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

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T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

0 ADJUSTED MONTHLY OR ANNUAL VALUE TOTAL CONTAINS ESTIMATED VALUE(S) FOR MISSING DATA.

A AMOUNT PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

5/10/91
5/15/
ETM
7/2/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)							NO. OF DAYS		
																				SNOW, SLEET					
YR.	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
85	1	40.4	15.3	27.9	2.2	1146	0	52	19	-6	31	0	3	31	1	.74	-1.21	.47	8	12.3	6	8	2	0	0
85	2	43.0	16.9	29.0	-1.8	1002	0	56	27	-11	1	0	6	28	5	.58	-.71	.29	9	7.5	4	5•	2	0	0
85	3	50.2	25.6	37.9	.7	831	0	65	25•	5	4	0	0	27	0	2.49	.97	.40	19•	11.5M	2	29•	9	0	0
85	4	64.8	31.9	48.4	3.4	494	0	77	15	25	23•	0	0	17	0	2.01	.80	.63	21	2.0	0T	30•	5	1	0
85	5	71.3	37.7	54.5	1.3	316	0	87	28	27	14	0	0	2	0	.91	-.17	.24	31	.0	0		3	0	0
85	6	85.2	43.9	64.6	3.1	59	49	93	23•	33	1	7	0	0	0	.24	-.35	.16	17	.0	0		1	0	0
85	7	86.9	51.9	69.4	1.1	3	147	95	5•	44	1	14	0	0	0	2.11	.41	.71	28	.0	0		5	2	0
85	8	86.9	48.3	67.6	1.4	8	97	92	31•	40	13	10	0	0	0	.24	-2.14	.10	20	.0	0		1	0	0
85	9	71.9	39.9	55.9	-2.9	274	8	88	1	24	30	0	0	7	0	2.87	1.35	.88	11	.0	0		7	2	0
85	10	65.4	33.8	49.6	.5	471	0	76	4•	25	15	0	0	15	0	1.98	-.09	.87	13	.0	0		4	2	0
85	11	46.3	22.1	34.2	-2.9	916	0	64	2	-1	19	0	1	28	1	2.57	1.23	.60	29	22.5	7	21	8	2	0
85	12	41.4	13.3	27.4	-.4	1159	0	38	29•	0	12	0	3	31	1	.34	-1.62	.25	10	5.1	4	10	1	0	0
	ANN.	62.6	31.5	47.2	.5	6679	301	95	JUL	-11	FEB	31	13	186	8	17.08	-1.53	.88	SEP	60.9M	7	NOV	48	9	0

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T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

92% of normal

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7/1/91
5/10/91
5/15/91
EMR
KK
7/2/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)							NO. OF DAYS		
		MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	SNOW, SLEET TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
	MO.																								
84	1	39.3	6.5	22.9	-2.6	1297	0	51	7•	-17	23	0	5	31	8	.90	-1.05	.79	14	11.5	17	14	1	1	0
84	2	45.2	14.8	30.0	-.8	1009	0	57	29	8	18•	0	1	29	0	.45	-.84	.20	17	4.4	5	10•	3	0	0
84	3	52.7	21.5	37.1	-.1	859	0	65	21•	3	27	0	0	30	0	1.02	-.50	.33	30	5.5	1	30•	4	0	0
84	4	57.9	27.3	42.6	-2.4	665	0	75	17	17	26	0	0	25	0	1.34	.13	.45	28	7.0	2	28	5	0	0
84	5	76.9	39.7	58.3	5.1	208	6	89	23	27	8	0	0	5	0	.49	-.59	.32	15	.0	0		1	1	0
84	6	80.0	44.1	62.1	.6	113	33	90	29•	33	9	3	0	0	0	1.20	.61	.49	5	.0	0		4	0	0
84	7	88.0	53.4	70.7	2.4	0	105	96	20•	47	4•	14	0	0	0	2.36	.66	.53	14	.0	0		5	2	0
84	8	84.1	51.4	67.8	1.6	6	99	91	29	47	27•	3	0	0	0	4.13	1.75	.65	31	.0	0		11	3	0
84	9	77.8	44.0	60.9	2.1	124	5	88	9	28	30	0	0	2	0	1.64	.12	.50	11	.0	0		5	1	0
84	10	54.1	30.5	42.3	-6.8	695	0	70	9•	19	18	0	0	19	0	4.03	1.96	1.22	17	17.0	5	17	9	3	1
84	11	50.0	21.7	35.9	-1.2	867	0	63	12•	3	27	0	1	30	0	1.04	-.30	.43	25	10.1	4	29•	5	0	0
84	12	40.8	19.4	30.1	2.3	1074	0	54	7	0	22	0	3	29	1	3.21	1.25	1.04	27	22.3	12	16	10	2	1
	ANN.	62.2	31.2	46.7	.0	6917	328	96	JUL	-17	JAN	20	10	200	9	21.81	3.20	1.22	OCT	77.8	17	JAN	63	12	2

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T TRACE

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5/10/9
5/15/91
7/2/9

U. . DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022.32 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)				SNOW, SLEET			NO. OF DAYS		
YR	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
83	1	41.7	14.9	28.3	2.6	1129	0	52	14•	0	1	0	0	31	1	1.00	-.95	.19	31	12.2	4	2•	5	0	0
83	2	45.1	19.6	32.4	1.6	907	0	58	23	2	6	0	1	28	0	1.85	.56	.59	4	20.5	10	4	6	2	0
83	3	49.4	25.3	37.4	.2	850	0	64	10	14	26	0	0	30	0	2.56	1.04	.49	18	23.0	5	24	9	0	0
83	4	54.2	26.5	40.4	-4.6	733	0	72	24	14	5	0	1	27	0	1.03	-.18	.45	30	8.5	2	4	3	0	0
83	5	68.5	35.0	51.8	-1.4	405	1	86	27	24	17•	0	0	11	0	.5.	-.51	.24	31	.0	0		2	0	0
83	6	78.4	41.9	60.2	-1.3	147	9	92	22	33	14	2	0	0	0	1.12	.53	.58	25	.0	0		2	1	0
83	7	87.8	51.3	69.6	1.3	7	153	94	6•	36	9	10	0	0	0	2.33	.63	.54	25	.0	0		7	1	0
83	8	85.9	53.5	69.7	3.5	0	153	92	16•	47	22	6	0	0	0	2.70	.32	.99	11	.0	0		5	2	0
83	9	79.0	42.8	60.9	2.1	139	24	92	6	15	7	1	0	3	0	2.33	.81	1.45	30	.0	0		4	1	1
83	10	65.4	33.2	49.3	.2	481	0	72	26•	25	23	0	0	15	0	.97	-1.10	.44	1	.0	0		3	0	0
83	11	48.1	21.2	34.7	-2.4	904	0	72	3	3	28•	0	4	27	0	3.11	1.77	.84	18	16.0M	11	26•	5	3	0
83	12	38.1	16.5	27.3	-.5	1162	0	47	11•	0	16	0	7	31	1	2.75	.79	.43	23	33.5	16	21	10	0	0
	ANN.	61.8	31.8	46.8	.1	6864	340	94	JUL	0	DEC•	19	13	203	2	22.32	3.71	1.45	SEP	113.7M	16	DEC	61	10	1

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

• OCCURRED ON ONE OR MORE PREVIOUS DATES DURING THE MONTH.

T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

D ADJUSTED MONTHLY OR ANNUAL VALUE TOTAL CONTAINS ESTIMATED VALUE(S) FOR MISSING DATA.

A ANNUAL PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

5/10/91
ETW
5/15/91
7/24/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

ANNUAL CLIMATOLOGICAL SUMMARY

NATIONAL CLIMATIC DATA CENTER
FEDERAL BUILDING
ASHEVILLE, NORTH CAROLINA
28801

STATION IDENTIFICATION

05022432 DURANGO COLORADO ELEVATION 6600 FT. ABOVE SEA LEVEL LAT. 37 17N LONG. 107 53W

DATE		TEMPERATURE (°F)										NUMBER OF DAYS				PRECIPITATION (INCHES)									
																				SNOW, SLEET			NO. OF DAYS		
YR.	MO.	MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	HEATING DEGREE DAYS	COOLING DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	MAX ≥ 90°	MAX ≤ 32°	MIN ≤ 32°	MIN ≤ 0°	TOTAL	DEPART. FROM NORMAL	GREATEST RECORDED DAY	DATE	TOTAL FALL	MAX DEPTH	DATE	≥.10	≥.50	≥1.0
82	1	36.0	8.9	22.5	-3.4	1311	0	51	26	-8	8	0	0	31	6	1.29	-.41	.50	5	21.5	13	6	5	1	0
82	2	43.0	14.7	28.9	-1.9	1004	0	61	22•	-13	6	0	4	28	5	1.86	.72	.40	24	25.0	15	10	6	0	0
82	3	49.7	25.4	37.6	1.0	844	0	62	25	14	20	0	0	25	0	2.96	1.49	.60	12	5.0	0		8	2	0
82	4	59.8	29.7	44.8	-.3	599	0	75	20	18	8	0	0	24	0	.64	-.72	M	M	4.0M	0		0	0	0
82	5	68.3	36.6	52.5	-.4	382	0	79	26•	26	6	0	0	5	0	1.45	.33	.74	5	.0	0		5	1	0
82	6	80.2	40.2	60.2	.0	145	10	89	28	30	6	0	0	3	0	.45	-.43	.19	30	.0	0		2	0	0
82	7	86.2	49.2	67.7	.2	24	114	95	22•	39	2	10	0	0	0	.99	-.86	.57	28	.0	0		2	1	0
82	8	84.0	53.0	68.5	2.5	6	122	93	19	45	29	5	0	0	0	2.74	.31	.58	12	.0	0		5	1	0
82	9	74.1	45.1	59.6	1.0	171	15	90	2	31	29	1	0	1	0	2.22	.63	.74	11	.0	0		5	2	0
82	10	62.2	27.8	45.0	-3.8	613	0	73	4	17	9	0	0	25	0	.58	-1.36	.44	26	.0	0		2	0	0
82	11	47.4	23.8	35.6	-1.3	874	0	62	7•	13	12	0	0	25	0	4.55	3.44	1.61	30	15.5	9	30	7	2	1
82	12	38.7	13.8	26.3	-1.7	1193	0	52	21	-7	29	0	3	29	3	1.78	-.22	.76	23	13.0	9	2•	5	2	0
	ANN.	60.0	30.7	45.0	-.7	7166	261	95	JUL	-13	FEB	16	15	196	14	21.51	2.92	1.61	NOV	86.4M	15	FEB	56	12	1

M MISSING DATA. APPEARS WITH MONTHLY DATA WHEN LESS THAN 10 DAYS ARE MISSING, AND IT APPEARS ALONE IF 10 OR MORE DAYS ARE MISSING. IT APPEARS WITH ANNUAL DATA, WHEN DERIVED FROM MONTHS WITH MISSING DATA.

• OCCURRED ON ONE OR MORE PREVIOUS DATES DURING THE MONTH.

T TRACE

V INCLUDES TOTAL FOR PREVIOUS MONTH.

0 ADJUSTED MONTHLY OR ANNUAL VALUE TOTAL CONTAINS ESTIMATED VALUE(S) FOR MISSING DATA.

A ANNUAL PRECIPITATION MAY INCLUDE PRECIPITATION THAT OCCURRED DURING THE PREVIOUS MONTHS.

5/10/91
Cag
ETM
5/15/9
KHF 5/16/9

STATION: 05-2432 CO DURANGO

TOTAL PRECIPITATION

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1951	1.62	.51	.91	1.17	.39	.00T	.99	1.19	.80	1.63	1.27	5.43	15.91
1952	3.48	.61	1.26	3.06	.32	1.54	2.38	2.92	1.60	.00	2.48	1.19	20.84
1953	1.59	.35	1.70	2.12	.64	1.05	2.28	2.48	.00T	3.18	1.77	1.12	18.28
1954	1.11	.21	2.24	.33	1.63	.68	4.16	1.63	3.03	1.11	.33	1.03	17.49
1955	2.01	2.17	.00T	1.19	2.49	.28	2.27	5.13	.72	.00T	1.15	2.13	19.54
1956	3.39	.50	.82	1.00	.02	.21	.75	.93	.13	1.60	.31	.53	10.19
1957	6.28	.87	1.63	2.89	2.90	.51	4.17	3.65	.09	4.08	3.85	1.48	32.40
1958	.97	1.95	3.26	1.15	.36	.66	.48	2.07	2.30	1.69	.85	.27	16.01
1959	.12	2.14	.16	1.00	.40	.59	2.10	4.82	.83	4.58	.53	3.82	21.09
1960	1.82	1.77	1.06	1.34	.72	.91	1.03	.48	1.40	3.83	.90	2.02	17.28
1961	.60	.56	4.08	.87	.35	.05	1.91	3.12	2.22	2.58	.85	1.39	18.58
1962	.78	2.29	.87	.24	1.24	.54	.53	.42	2.46	2.73	1.67	1.63	15.40
1963	2.53	1.26	1.00	1.32	.18	.24	2.97	5.17	1.03	1.77	.88	.42	18.77
1964	.56	.48	2.29	1.84	.33	.10	2.13	3.75	2.07	.00T	1.52	3.10	18.17
1965	2.03	1.64	1.73	3.35	1.67	1.26	1.98	2.13	1.85	1.07	2.83	4.76	26.30
1966	.49	1.23	.54	.96	.88	.43	.87	3.44	1.14	.48	1.44	5.36	17.26
1967	.93	.12	.43	.08	.68	1.19	2.72	3.53	1.23	.08	.54	4.03	15.56
1968	1.49	1.36	1.11	1.17	2.14	.14	2.75E	1.10	.09	1.32	.94	1.73	15.34E
1969	3.59	1.89	1.14	.22	.87	2.44	1.96	1.53	1.72	3.51	.96	.45	20.28
1970	.26	.14	2.52	.41	.03	1.65	2.23	2.19	4.53	.96	1.43	1.19	17.54
1971	.44	.54	.07E	.71	1.69	.00	1.16	4.14	2.16	2.63	1.46	3.35	18.35E
1972	.22	.00T	.23	.33	.19	1.55	.75	2.67	1.22	11.79	2.57	2.34	23.86
1973	1.52	.93	3.44	1.44	.96	1.19	1.42E	2.64	1.62	.48	.89	.51	17.04E
1974	3.02	.17	.25	1.06	.00	.00	1.41	.85	1.11	5.92	.34	.89	15.02
1975	1.59	1.78	3.59	2.73	1.21	.15	1.22	.73	1.98	.35	1.15	1.67	18.15
1976	.14	3.77	.75	.92	2.30	.08	.77	2.08	3.14	.25	.01	.05	14.26
1977	1.48	.11	.09	.53	1.01	.09	2.39	1.53	1.32E	.91	1.30	.41	11.17E
1978	3.19	2.68	3.12	1.38	2.99	.18	.38	1.85	1.76	1.60	3.97	4.23	27.33
1979	4.24	1.91	3.72	.65	1.72	.13	.38	2.27	.17	.89	.93	1.78	18.79
1980	6.94	4.80	1.57	.87	2.01	.00	.33	1.02	1.80	1.17	.97	.50	21.98
SUM	58.43	38.74	45.58	36.33	32.32	17.84	50.87	71.46	45.52	62.19	40.09	58.81	550.18
NO YRS	30	30	30	30	30	30	30	30	30	30	30	30	30
MEAN	1.95	1.29	1.52	1.21	1.08	.59	1.70	2.38	1.52	2.07	1.34	1.96	18.61
EXT HI	6.94	4.80	4.08	3.35	2.99	2.44	4.17	5.17	4.53	11.79	3.97	5.43	32.40
EXT LO	.12	.00T	.00T	.08	.00	.00	.33	.42	.00T	.00	.01	.05	10.19
EST	0	0	1	0	0	0	2	0	1	0	0	0	4

KHL 7/21/91

5/20/91
5/15/91

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
(CC FORM 5443)

ANNUAL CLIMATOLOGICAL SUMMARY

ENVIRONMENTAL DATA SERVICE
NATIONAL CLIMATIC CENTER
NOAA FORM 37-528 7-(1-76)

STATION NUMBER 05 2432 02 DURANGO COLORADO ELEVATION 0 6600 FT. ABOVE SEA-LEVEL. LAT. 37 17 N LONG. 107 53 E

DATE YR	MO	TEMPERATURES (°F) MEAN MAXIMUM	MEAN MINIMUM	MEAN	DEPART. FROM NORMAL	DEGREE DAYS	HIGHEST	DATE	LOWEST	DATE	NUMBER OF DAYS MAX. ≥ 90°	MAX. ≤ 32°	MIN. ≤ 32°	MIN. ≤ 0°	PRECIPITATION (INCHES) TOTAL	DEPART. FROM NORMAL	GREATEST OBSERVED DAY	DATE	SNOW, SLEET TOTAL FALL	GREATEST DEPTH	DATE	NO. OF DAYS ≥ .10	≥ .50	≥ 1.00
81	01	50.6	16.5	33.6	7.7	968	61	22	8	31	0	0	31	0	.12	- 1.58	.07	29	3.0			0	0	0
81	02	51.7	17.6	34.7	3.9	842	66	18	5	11+	0	0	28	0	.79	- .35	.63	26	7.0	1	26	2	[illegible]	[illegible]
81	03	60.7	23.3	36.0	- .6	891	61	26	15	7	0	0	31	0	3.03	1.58	.73	11	29.0	6	13	0	2	[illegible]
81	04	65.6	32.1	48.9	3.8	478	81	30	16	5	0	0	15	0	1.21	- .15	.47	14	2.0	0		0	0	[illegible]
81	05	65.5	37.6	51.6	- 1.3	409	78	2	27	8	0	0	6	0	1.69	.87	.47	16	.0	0		0	0	[illegible]
81	06	82.0	45.7	64.4	9.2	82	93	25+	36	17+	7	0	0	0	.87	- .31	.27	30	.0	0		0	0	[illegible]
81	07	85.4	53.4	69.4	1.9	9	93	21+	43	28	7	0	0	0	3.24	3.51	1.14	9	.0	0		0	0	[illegible]
81	08	83.2	49.9	66.6	.6	23	97	6	44	19	4	0	0	0	1.97	- .63	.80	32	.0	0		0	0	[illegible]
81	09	77.6	44.3	61.0	2.4	120	84	3	35	27	0	0	0	0	2.55	.96			.0	0		0	0	[illegible]
81	10	61.6	33.7	47.7	- 1.1	531	73	6	19	31	0	0	13	0	3.53	1.59	.95	3	T	0		0	0	[illegible]
81	11	55.4	23.3	39.4	2.5	764	65	16	13	26	0	0	29	0	1.26	.15	.68	29	4.5	3	27	0	0	0
81	12	44.6	17.4	31.0	3.0	1047	62	9	2	24	0	3	31	0	.47	- 1.53	.27	30	6.0	0	31	0	0	0
81	ANN	64.4	32.9	48.7	2.3	6164	97	8	2	12	18	3	184	0	22.57	3.98	1.14	7	51.0	0	3			
		ANNUAL MEANS				SUM	ANNUAL EXTREMES				ANNUAL SUMS						EXTREME		SUM	EXTREME		SUMS		
						2.3																		
		SUM	SUM	SUM	NORMAL	DEP.	DIFF.	ERROR							NORMAL	DEP.	DIFF.	ERROR						

"-" = MISSING DATA
"+" = AFTER DATE; ALSO OTHER DAYS
T = TRACE

END

DATE FILMED

9/15/93